Performance Analysis of LMS Algorithm for Different Fading Channel

[1]Pratyushna Singh, [2]Anupama Senapati, [3]Jibendu Sekhar Roy

[1]MTech Student, [2]Assistant Professor, [3]Professor

[1]School of Electronics Engineering,

[1]Kalinga Institute of Industrial Technology, Deemed to be University, Bhubaneswar, India

Abstract : This paper presents performance evaluation of adaptive beamforming algorithm like least mean square (LMS) for Rayleigh and Rician fading channels. BER analysis for different SNR value is done. Adaptive beamforming of smart antenna with fading environment using least mean square algorithm and its convergence rate analysis is done for WiMAX application. Performance of LMS algorithm is better for Rician channel with increased K value.

IndexTerms **- Smart Antenna, beamforming, Rayleigh fading, Rician fading, bit error rate, WiMAX**

I. INTRODUCTION

The wireless industry in last few years has seen a remarkable development by improving the infrastructures to meet the demand of users and significant advancements for the implementation of wireless technology have been made ,but some inescapable conditions attenuate the signal energy and hinder the desired outcomes from the system. Information is passed from transmitter to receiver (source to destination) through a channel. This communication channel can be either a simple line-of-sight or the one in which the transmission or reception of data is severely hurdled by the obstacles like buildings, mountains etc and this results in multipath fading. Multipath fading affects the performance of the system.

Smart antenna uses array of elements with digital signal processing algorithms and signal received at each antenna element is combined to increase the overall performance of system[1-4].The algorithms identify the direction of arrival of signal. After identification of DOA of signal the beamforming network of antenna array locates the antenna beam towards the target [5-7]. Two main functions of smart antenna are direction of arrival (DOA) estimation and beamforming. Smart antenna produces main beam along the desired direction and null towards the undesired direction [8-9]. A sequential quadratic programming based algorithm is used for multi lobe pattern and for adaptive nulling of the pattern in [10]. A beamforming technique for precise DOA estimation based on hybridization of soft computing methods is reported in [11]Comparative analysis of multiple modulation schemes in rayleigh faded channelsusing beamforming technique [12].WiMAX is one of the most popular broadband wireless technology that is used enormously [13]. Knowledge about WiMAX technology its security and applications .Information about threats in different layers of WiMAX is reported in [14].Rician K-factor and RMS Delay Spread (RDS) are two main parameters those characterize a multipath fading channel.Effects of antenna beamwidth, RDS, Rician-K and other channel parameters on LTE-OFDM channels are investigated and presented in this paper[15] through theoretical analysis and simulations of channel models.

In this paper, smart antenna is designed for WiMAX application considering multipath fading channel for linear antenna array. In section II, a description on beamforming algorithms is written. Section III covers two fading channels - Rayleigh fading and Rician fading. In section IV, simulation part is shown. Section V is conclusion and future scope of work.

II. BEAMFORMING ALGORITHMS

Adaptive algorithm like LMS is used to minimize the error er(n) between desired signal S(n) and array output y(n) [8]

$$er(n) = S(n) - y(n) \qquad \text{……(1)}$$

Output of adaptive beam former, at time n, is a linear combination of the data at the N antenna elements, can be expressed as [8]

$$y^H(n) = w^H x(n) \qquad \text{…… (2)}$$

Where w^H refers to Hermitian transpose of complex weight vector w.

Signal received by array of antenna is [8]

$$x(n) = [x_1(n), x_2(n) \ldots\ldots x_N(n)] \qquad \text{……(3)}$$

Least Mean Square (LMS) algorithm is a steepest descent method, where iterative procedure is used making successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error.

Weight updating equation for LMS algorithm is given by

$$w(n+1) = w(n) + \mu x(n) e^*(n) \qquad \text{……(4)}$$

Where µ is the step size.

Figure 1 shows a block diagram of LMS algorithm.

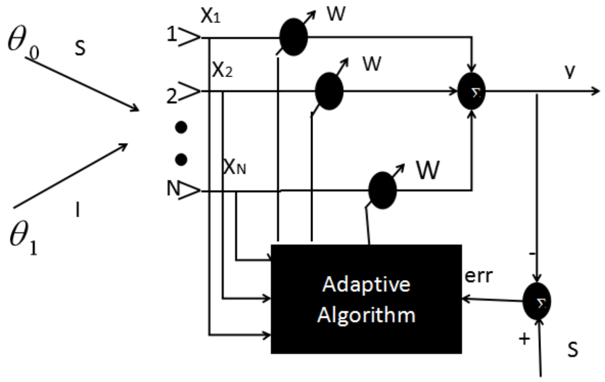

Fig. 1 Block Diagram of LMS algorithm

III. Rayleigh Channel and Rician Channel

In case of non line of sight (NLOS) communication between transmitter and receiver, signals may attenuate, reflect, refract and diffract. A Rayleigh fading channel occurs when there are various signal paths between the transmitter and receiver, but none of them is dominant. The probability density function of Rayleigh channel with received signal envelope f(r) is $f(r) = re^{-r^2/2\sigma^2} / \sigma^2$ where f(r) is the time average power of received signal before envelope detection. r is the envelope of Rayleigh fading .

If there is line of sight between transmitter and receiver then the propagation environment follows Rician. The probability density function of Rician channel is $p(r_0) = \frac{r_0}{\sigma^2}\exp\left[\frac{(-r_0^{\ 2} + A^2)}{2\sigma^2}\right] I_0\left[\frac{r_0 A}{\sigma^2}\right]$ for $r_0 \geq 0, A \geq 0$ where $I_0(.)$ is the modified Bessel function of zero order. A is the peak magnitude of line of sight signal component. In Rician channel fading K factor is one of that input that defines ratio of power of line of sight distribution and multipath components $K = A^2/2\sigma^2$ when K is zero, Rician fading channel becomes Rayleigh fading.

IV. Performance Evaluation of LMS Algorithm for Different Fading Channels

Array factor of a uniform linear antenna array can be expressed as [8-9]

$$AF = \sum_{n=0}^{N-1} A_n e^{(jn(\frac{2\pi d}{\lambda}\sin\theta + \alpha))} \qquad \text{....................................(5)}$$

Where to generate the main beam at wavelength λ toward the desired beam direction θ_0 from the broadside direction, the progressive phase shift is

$$\alpha = \frac{-2\pi d}{\lambda}\sin\theta_0$$

Normalized array factor is

$$AF_{norm} = \frac{AF}{AF_{\max}}$$

Figure shows a uniform linear antenna array (ULA) with inter-element spacing of d.

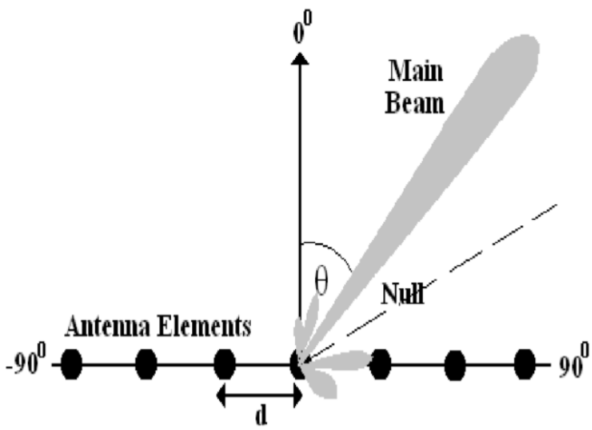

Fig. 2 Uniform linear configuration

WiMAX stands for *Worldwide Interoperability for Microwave Access*. WiMAX technologies are widely accepted as a cost effective and reliable solution for delivering wireless broadband services [13]. WiMAX is based on a next generation all IP core network, which offers low latency, advanced security, QoS (Quality of Service).

WiMAX provide high speed connectivity that can be used for long distance communication with higher data rates. Different bands are available for WiMAX applications in different parts of the world. The frequencies commonly used are 3.5 and 5.8 GHz for 802.16d and 2.3, 2.5 and 3.5 GHz for 802.16e but the use depends upon the countries.

The frequency OF WiMAX used in this paper for smart antenna designing is 3.5 GHz.

Block diagram of BPSK fading channel is shown in figure 3.

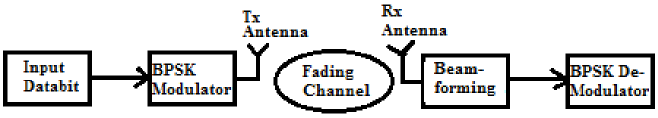

Fig. 3 Block Diagram of BPSK Fading Channel

IV. SIMULATION RESULTS

In this section simulation results are carried out using MATLAB. Figure 4 shows bit error rate plot for Rayleigh channel and Rician channel for different Rician factors.

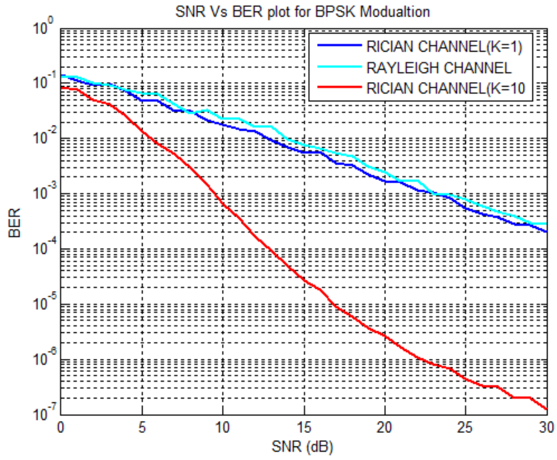

Fig. 4 SNR Vs BER PLOT

The simulated results of figure 4 are tabulated in Table 1.

TABLE I
BER values for Rayleigh and Rician Channel

SNR	0	5	10	15	20	25	30
BER for RAYLEIGH CHANNEL	0.1	0.06	0.02	0.008	0.002	0.0006	0.00021
BER for RICIAN CHANNEL(K=1)	0.1	0.04	0.02	0.006	0.001	0.0005	0.00018
BER for RICIAN CHANNEL(K=10)	0.1	0.01	0.0007	0.0000275	0.00000270	0.0000004425	0.0000001191

It is observed in figure 4 the bit error rate decreases with increase in SNR value and with increase in Rician factor 'K' bit error rate decreases faster. If we compare both the fading channel condition Rayleigh fading channel and Rician fading channel, bit error rate decreases faster in case of Rician fading channel. From the table 1 it is observed that BER value goes on decresing with increase in SNR value and lowest when SNR is 30dB .BER value is 0.00021 for Rayleigh channel ,for rician channel (K=1) it is 0.00018 and for rician channel(K=10) it is 0.0000001191 for SNR 30 dB.

The radiation pattern is simulated for Rayleigh channel and Rician channel with Rician factors 1 and 10 for uniform linear antenna array of 10 elements which is designed for WiMAX application at 3.5GHz. Simulations are done with step size of 0.02 for LMS algorithm and considering multiple interferers. Two such cases are taken and results are shown in from figure (5-6).

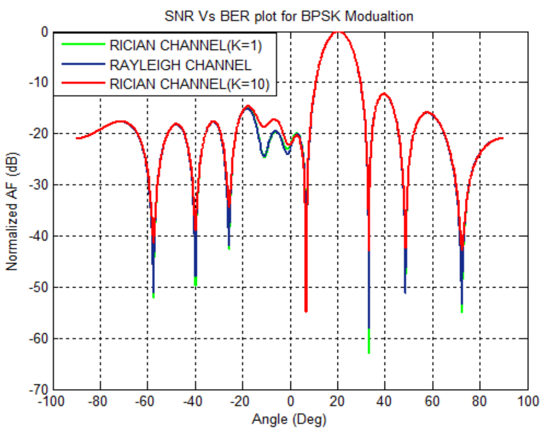

Fig. 5 Normalized AF for desired user at 20^0 and interferer at 0^0,-10^0

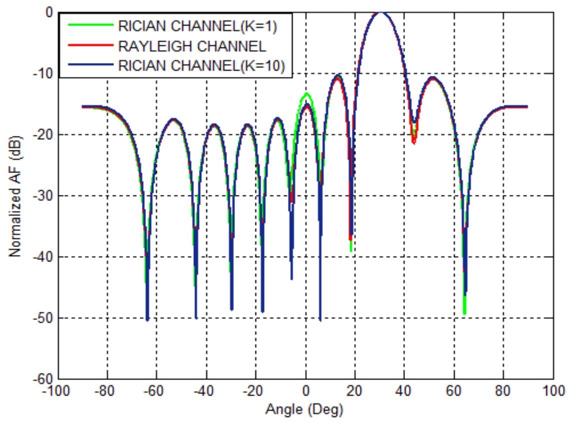

Fig. 6 Normalized AF for desired user at 30^0, and interferer at 20^0, 45^0

Results from figure 5 and figure 6 are summarized in Table II.

TABLE III

Performance evaluation of LMS algorithm for beamforming with Rayleigh and Rician channel

	Channel	Main Beam (Degree)	Null1 (Degree)	Null2 Degree	SLL_{max} in dB	FNBW (Degree)
Set-1	Rician Channel for K=1	20	-10.6	0.6	-12.3	26.2
	Rician Channel for K=10	20	-10.2	0.4	-12.2	26.4
	RAYLEIGH	20	-10.8	0.2	-12.3	27.4
Set-2	RAYLEIGH	30	18.4	44.2	-11	25.8
	RICIAN FOR K=10	30	18.8	44.6	-10.5	25.6
	RICIAN FOR K=1	30	18.6	44.8	-10.8	26.2

Smart antenna is designed for WiMAX application. Adaptive beamforming is done for linear antenna array with Rayleigh fading and Rician fading channel havingrician factor K=1 and K=10. It is found that main beam is achieved as desired and nulls are achieved at a deviation of less than 20% from desired direction for both the cases.

The convergence rate is simulated for Rayleigh channel and Rician channel with Rician factors K=1 and K=10 with 10 array elements, Step size=0.02 and multiple interferers and no of iterations is taken as 100. which is shown in from figure (7-9).

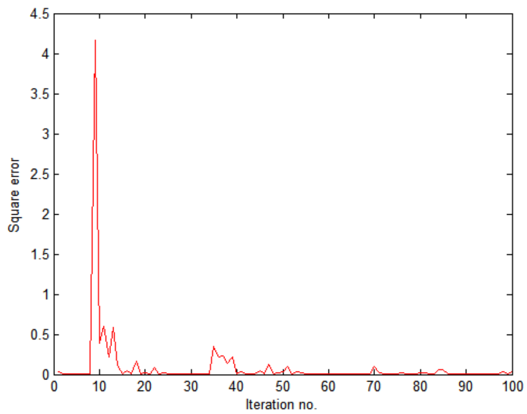

Fig. 7 Square error plot for Rayleigh channel

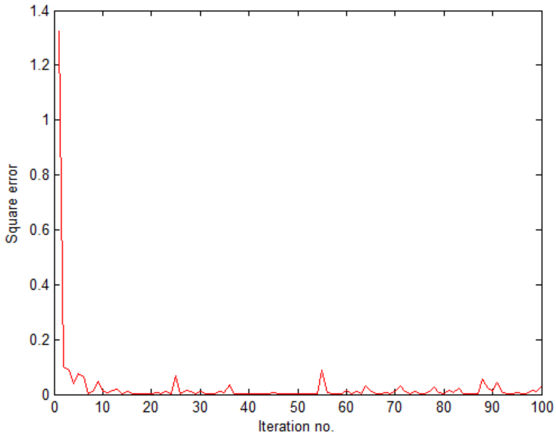

Fig. 8 Square error plot for Rician channel (K=1)

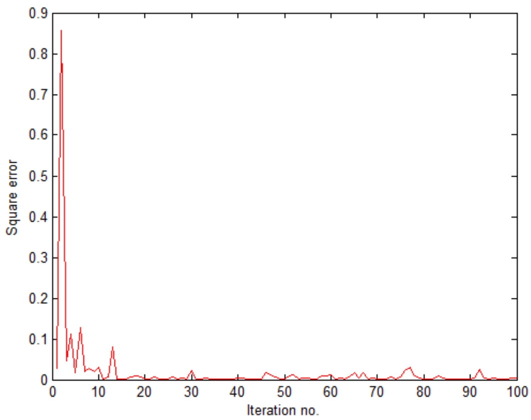

Fig. 9 Square error plot for Rician channel (K=10)

Square error is less for Rician channel with higher K value.

V. CONCLUSION

In this paper a comparative study between Rayleigh fading channel and Rician fading channel with different Rician factors and adaptive beamformation of smart antenna for WiMAX application with different fading channels is presented. LMS algorithm performs good for different fading channels, i.e., beam is formed as desired. With increase in SNR value, bit error rate decreases. It is found bit error rate performance of rician fading channel is better than Rayleigh fading channel. For Rician channel with increase in K value BER decreases faster. For all the fading channels main beam is achieved as desired and nulls are achieved at a deviation of less than 20% from desired direction and it is observed that with increase in number of iterations the square error value decreases for all the fading channels considered. An improvement in square error is achieved for increase in K value.

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