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Analysis of Bit Error Rate on M-ary QAM over Gaussian and Rayleigh Fading Channel

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***Abstract:** Transmission of signal over long distance through the channel will result in poor signal quality reception at the receiver. The Signal quality is affected by means of fading and it can be minimized by using effective modulation techniques. M-ary QAM is one of the effective modulation techniques as it has higher efficiency and effective form of modulation for data. M-QAM is a modulation where data bit selects M combinations of amplitude and phase shifts that are applied to carrier. The analysis carried out based on Bit Error Rate on various M - Quadrature Amplitude Modulation schemes like 16 -QAM, 64-QAM and 256- QAM over Gaussian and Rayleigh Fading channel. The input data entered into QAM modulator then transmits over Gaussian channel and the QAM demodulator is performed at the receiver. The same process repeated over Rayleigh fading channel for M-QAM. Rayleigh fading is multipath fading channel will vary randomly according to the Rayleigh distribution. The MATLAB simulation is carried out to get experimental results on M-QAM and compared. The analysis shows that improved Bit Error Rate in 16-QAM over Gaussian and Rayleigh fading channel.*

***Keywords:** Bit Error Rate, Fading, Gaussian, M-QAM*

I. INTRODUCTION

Signal transmitted through wireless channel is interfered due to path loss, shadowing and this leads to fading. Effective modulation techniques will minimize this fading effect. Digital Modulation techniques are the effective modulation techniques for the current wireless systems. M-QAM is efficiently used by encoding wave bit per symbol for a given energy level. M-QAM is widely used by wireless systems. Good spectral efficiency, Fade rejection and Noise immunity, high spectral efficiency, power efficiency, bit error rate performance are important features of M-QAM. These properties of M-QAM play an important role to resist fading on wireless communication. To simulate the background noise during signal transmission, the Additive White Gaussian channel is used in addition to multipath Rayleigh Fading channel and widely used to describe the signal when there is no line of sight between transmitter and receiver. The following sections are described in detail: II. Literature Survey, III. AWGN and Rayleigh Fading distribution. IV. Simulation Process, V. Results and Graphs obtained from simulation of MAT LAB.

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II. LITERATURE SURVEY

Lit[1] describes about error performance of M-QAM by using FFT,IFFT. The channel estimation done on pilot-aided, Rayleigh fading channel described on Clarke and Gans model. The results indicate that there is an increase in error rates as the M value increases. It is also observed that the error rate in Rayleigh fading channel is also higher compared to AWGN channel.

Lit[2] describes about BER of QAM-OFDM by using constellation diagram and the simulated data compared with the help of MAT LAB simulation tool.

Lit[3] describes about the studies done on QAM like SQAM and TQAM compared to AWGN and Nakagami-m fading channels, the subsequent BER or SER are obtained and on which highly approximated BER is achieved. The results shown optimum angles minimized the SER or BER for the specific order of M.

Lit[4] describes about the SER performance of RS Code over AWGN channel achieved simulated results effective than theoretical results for small codes. This paper also details about using RS code for long codes resulting in complicated error pattern with higher error rates.

III. AWGN AND RAYLEIGH FADING CHANNEL DISTRIBUTION

A. AWGN

Thermal noise is generated by the agitation of electrons in the input resistance of the amplifier and is described by certain statistical characteristics. This noise has a spectrum with all the frequency components, as in white light and hence it is called white noise. Another characteristic of the thermal noise is its probability distribution function, which is Gaussian. i.e., the plot of probability of occurrence against the level has a bell shape. The noise adds to signal power and hence is additive. And the noise is termed as AWGN.

B. Rayleigh Fading Channel Distribution

Rayleigh fading [2] Model is a statistical approach for signal propagation, Signal transmitted through this model, results in variation or fading in Rayleigh distribution is the sum of two uncorrelated Gaussian random variables. It is also suitable for the tropospheric radio propagation. Rayleigh fading manifests in to two mechanisms Time spreading and Time Invariant. Rayleigh distribution used to model fading in wireless communication. The random variable that describe the received signal strength has Rayleigh distribution. Rayleigh distribution is also used in the field of oceanography and at wind turbines to model the frequency of wind speeds for a year.

The Rayleigh PDF is

$$p(r) = \begin{cases} \frac{r}{\sigma^2} e^{\frac{-r^2}{\sigma^2}}, & for\ r > 0 \\ 0, & otherwise \end{cases} \quad (1)$$

where 'r' represents the envelop amplitude of received signal and $2\sigma^2$ is the power of the signal.

IV. SIMULATION PROCESS

Figure 1 represents the block diagram of the QAM modulator and demodulator. The input messages first enter into QAM modulator in which M-ary QAM like 16-QAM,64 QAM,256-QAM are implemented then modulated signal transmitted over Gaussian channel and received data compared with transmitted data and BER obtained. The procedure again implemented on Rayleigh fading channel When the signal is transmitted over Gaussian channel performance of Bit error rate has improved. The performance of the Bit Error Rate is lesser than the Gaussian channel when the same procedure is repeated over the Rayleigh fading Channel .

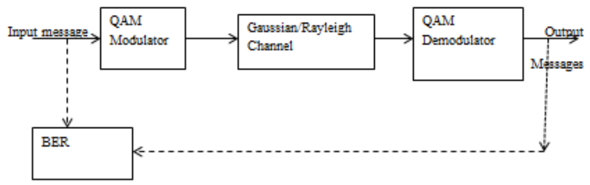

Fig 1: Block diagram QAM Modulator and Demodulator

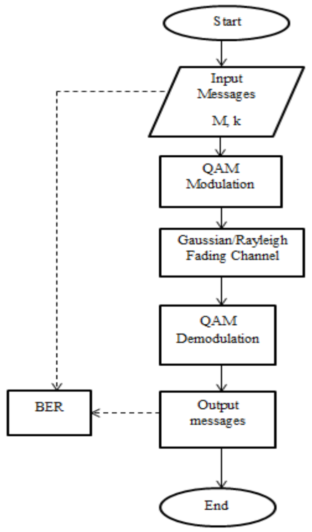

Fig 2: Simulation Flow chart

Figure 2 represents the simulation flow to analyse the bit error rate.The Simulation process flow of the proposed method.Input messages contain the number of messages (k) and M ary data. The QAM modulator performs the 16-QAM, 64-QAM and 256- QAM based on the number of messages and transmits over Gaussian channel. The signal is affected due to external noise and noisy signal received by the QAM receiver. Reverse process happens in the QAM receiver when output messages are received. There is signal interference due to multipath fading when the same process executed over Rayleigh Fading channel.The effective analysis of BER is done by comparing the input and output received messages. The MAT lab simulation function helps to find the BER of the corresponding M-QAM over different channel environment. The results obtained are clearly shown in the Section V in graphical form for further analysis.

V. RESULTS AND DISCUSSION

Bit error rate is the key factor to measure any digital receiver output. Bit Error Rate Vs E_b/N_0 results are obtained over Gaussian and Rayleigh Fading channel for 10 dB and 20 dB are the following.

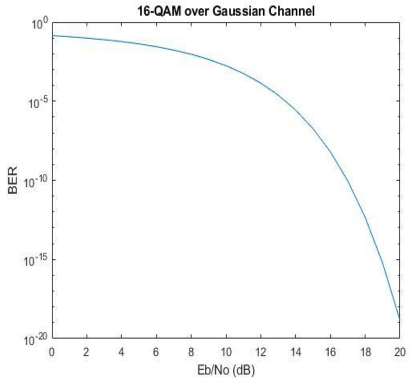

Fig. 3. BER of 16-QAM over Gaussian

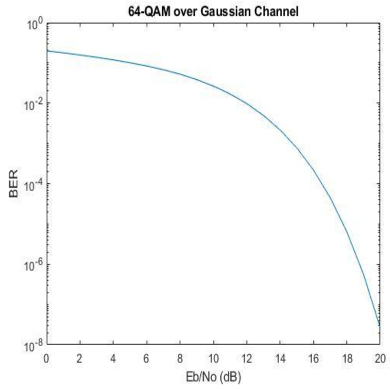

Fig. 4. BER of 64-QAM over Gaussian

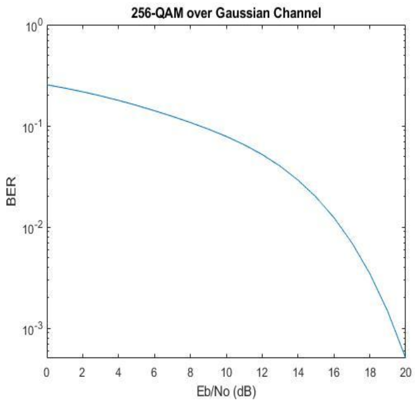

Fig. 5 BER of 256-QAM over Gaussian

The above results indicate the comparison of E_b/N_0 with Bit Error Rate for 10dB and 20dB for Gaussian Channel. As the E_b/N_0 value increases from 0 to 10 dB there is less difference between all the three QAM.

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Wherein when it reaches towards to 20 dB,16-QAM shown better BER of almost close to 10^{-20} than other 64,256-QAM.

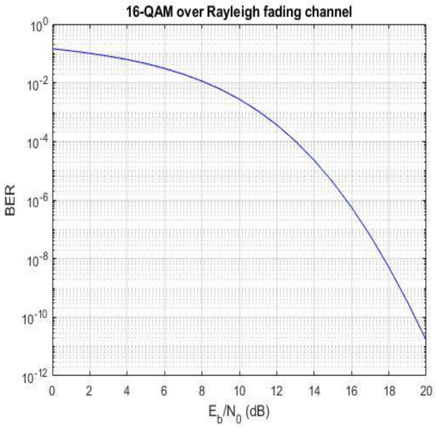

Fig 6: BER of 16-QAM over Rayleigh

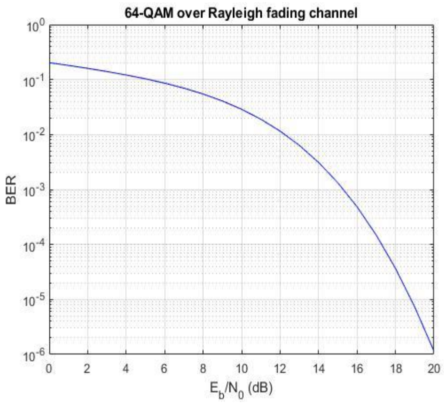

Fig 7: BER of 64-QAM over Rayleigh

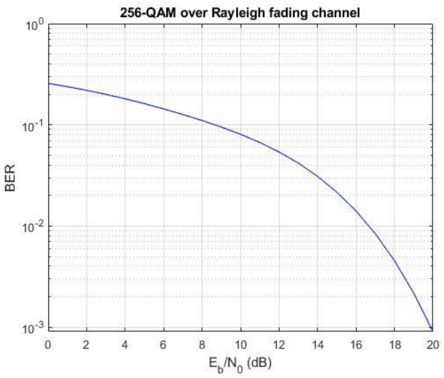

Fig 8: BER of 256-QAM over Rayleigh

The results obtained over the Rayleigh fading channel indicates the same behaviour as the Gaussian channel. It is observed from the above graph that the response obtained for 64and 256 –QAM are similar. But Similar to previous channel from the above figure observed that bit error rate is good in 16-QAM for 20dB**.** The results are shown in the following tables.

Table- I: E_b/N_0 Vs BER of 256- QAM

Channel	E_b/N_0(dB)	BER(256-QAM)
Gaussian	10	0.0786
	20	0.0005053
Rayleigh	10	0.08046
	20	0.0009043

Table- II: E_b/N_0 Vs BER of 64- QAM

Channel	E_b/N_0(dB)	BER(64-QAM)
Gaussian	10	0.02653
	20	2.634e-08
Rayleigh	10	0.08046
	20	0.0009043

Table- III: E_b/N_0 Vs BER of 16- QAM

Channel	E_b/N_0(dB)	BER(16-QAM)
Gaussian	10	0.001754
	20	1.404e-19
Rayleigh	10	0.002728
	20	1.632e-11

From above three tabular columns gave the clarity on various QAM that though it is a faded or non -faded environment as the E_b/N_0(dB) value increases the improved Bit Error Rate can be achieved only for lower M-QAM techniques.

VI. CONCLUSION

One of the effective Digital Modulation techniques The main objective of the system is achieved through the analysis of Bit Error Rate performance of M-QAM modulation techniques over Gaussian & Rayleigh fading channel. Due to the faded environment the results which obtained clearly indicate that out of three QAM which considered in the analysis 16-QAM gave better results on Gaussian and Rayleigh fading channel. The performance of Bit error rate will improve by using effective suitable channel coding techniques over faded environment.

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