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Performance Analysis of Rectangular 16-QAM in AWGN Channel

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Abstract– **This paper reports on detailed performance analysisof coherent rectangular 16-ary quadrature amplitude modulation corrupted by additive white Gaussian noise (AWGN). The main aim is to design a wireless system which will provide trade off between bandwidth and signal to noise ratio. For high spectral efficiency it is necessary to use QAM i.e. quadrature amplitude modulation which will provide high spectral efficiency. Although QAM appears to increase the efficiency of transmission for radio communication systems by utilizing amplitude and phase variations but signal is corrupted by noise and signal to noise ratio decreases so for reliable communication and to maintain appropriate value of signal to noise ratio it is required to decreases the spectral efficiency for given bandwidth. This report explores appropriate value of Signal to Noise Ratio for a given Bandwidth which is useful to make a practical realization of Quadrature Amplitude Modulation transmitter and receiver circuit as per the quality and cost is concern.**

I. INTRODUCTION

M-level quadrature amplitude modulation (*M*-QAM)provides high spectral efficiency and is thus widely employed in many wireless applications. Quadrature amplitude modulation (QAM) is both an analog and a digital modulation scheme. It conveys two analog message signals, or two digital bit streams, by changing (*modulating*) the amplitudes of two carrier waves, using the amplitude-shift keying (ASK) digital modulation scheme or amplitude modulation (AM) analog modulation scheme. These two waves, usually sinusoids, are out of phase with each other by 90° and are thus called quadrature carriers or quadrature components — hence the name of the scheme. Constellation diagram for rectangular 16-QAM. Rectangular QAM constellations are, in general, sub-optimal in the sense that they do not maximally space the constellation points for a given energy. However, they have the considerable advantage that they may be easily transmitted as two pulse amplitude modulation (PAM) signals on quadrature carriers, and can be easily demodulated, the performances of some M-ary modulation formats in frequency-flat fading and non-fading channels without diversity were analyzed assuming minimum mean-squared-error channel estimation (MMSE-CE).

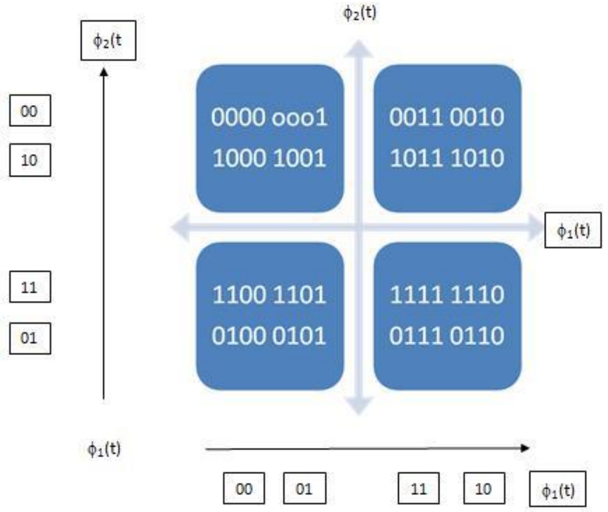

Fig. 1 Constellation Diagram of Rectangular 16-ary QAM

II. SYSTEM MODEL

The block diagram for both the transmitter and the receiver is shown in Figure below.

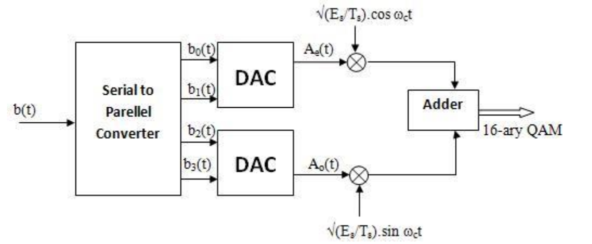

Fig. 2 Block Diagram of the QAM Transmitter

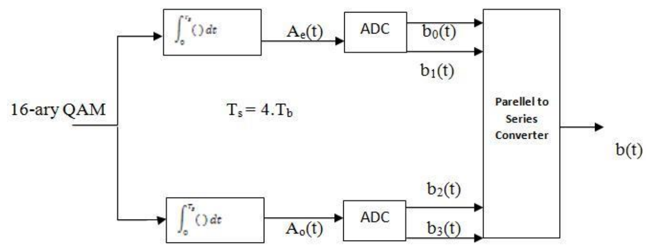

Fig. 3 Block Diagram of the QAM Receiver

System model is realised using MATLAB tool and analysed, numerical values uploaded to different curves and graphs. System model is shown as follows.

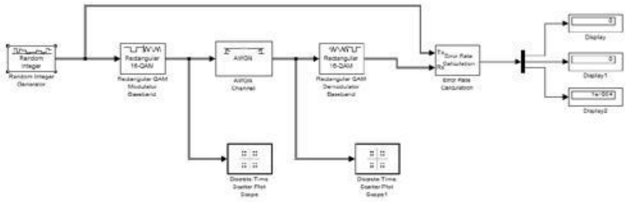

Fig. 4 System Model of rectangular 16-QAM in MATLAB

It assumed that non -fading channels without diversity were analyzed assuming minimum mean -squared-error channel estimation (MMSE-CE) and signal is corrupted only by additive white Gaussian noise (AWGN).

III. PERFORMANCE ANALYSIS

Probability of error of M-ary QAM is given as below.

/ = — η

− = 2 ◆1 − √ ◆◆2(−3 1)◆

Where E_S is average energy in first quadrant and η is noise power spectral density (W/Hz).

Expressions for the symbol-error rate of rectangular QAM are not hard to derive but yield rather unpleasant expressions. For an even number of bits per symbol, k , exact expressions are available. They are most easily expressed in a *per carrier* sense:

$$P_{sc} = 2\left(1 - \frac{1}{\sqrt{M}}\right) Q\left(\sqrt{\frac{3}{M-1}\frac{E_s}{N_0}}\right)$$

$$P_s = 1 - (1 - P_{sc})^2$$

A. Discrete-Time Scatter Plot Scope

Discrete-Time scatter plot scope shows in the Fig. 5 and Fig. 6 the difference between transmitted and received signal. This difference in the transmitted and received signal occurred by additive white Gaussian noise.

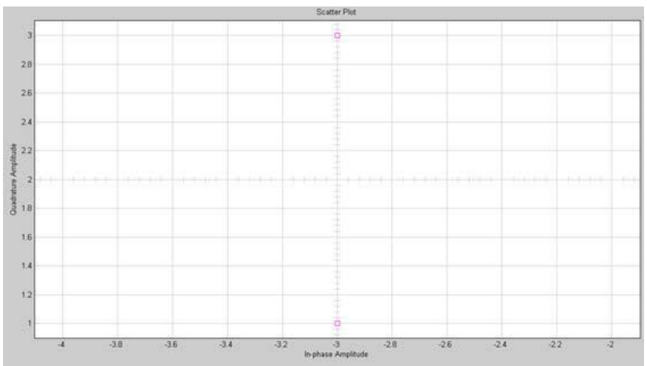

Fig. 5 16-ary QAM modulated transmitted signal

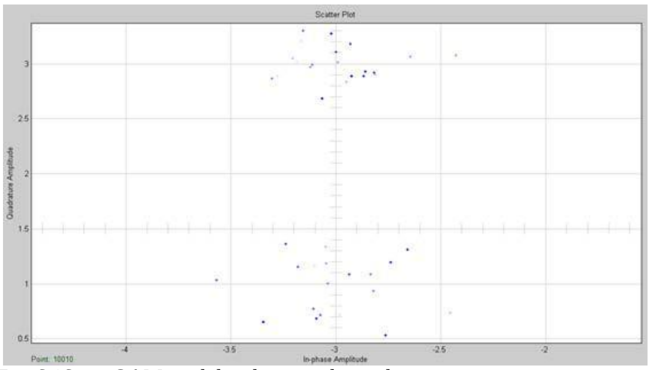

Fig. 6 16-ary QAM modulated received signal

B. System Quality and Efficiency parameters

Under the varying channel condition system efficiency parameter also varies. System quality and efficiency parameters depends upon the Signal to Noise Ratio (SNR), initial seed value and E_b/N_0 value. Error Rate value with respect to the various values of SNR, initial seed and E_b/N_0 is given below.

1) Signal to noise vs. Error rate

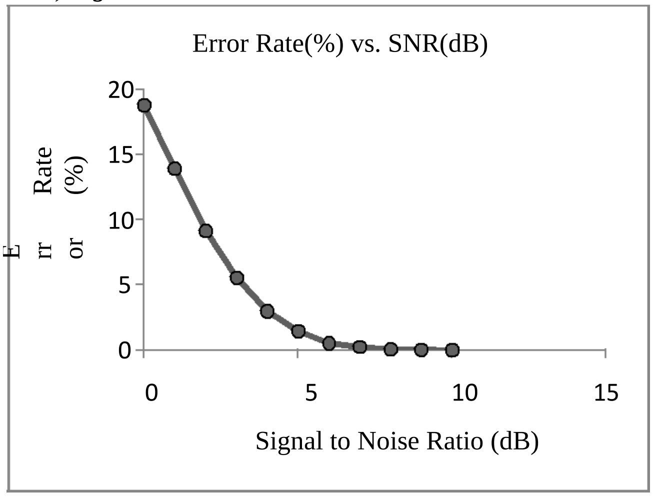

Fig. 7 signal to noise ratio vs. error rate I

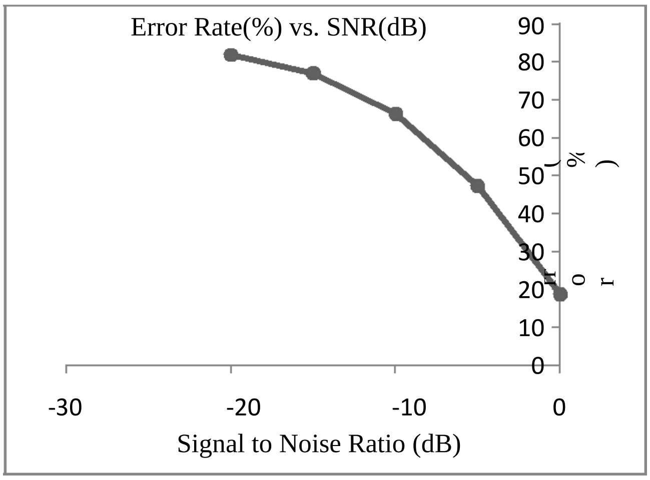

Fig. 8 signal to noise ratio vs. error rate II

Corresponding Fig. 7 & Fig. 8 shows the significance of Signal to Noise Ratio to the Error Rate of QAM system in more detail. Fig. 7 is for the positive value of SNR (in dB) and Fig. 8 is for negative values of SNR (in dB).

2) Signal to noise vs. Initial seed

Fig. 9 shows the significance of Initial Seed value to the Error Rate of QAM system in more detail. Fig. 9 shows that there is not any significant change in the Error Rate as value of Initial Seed varies.

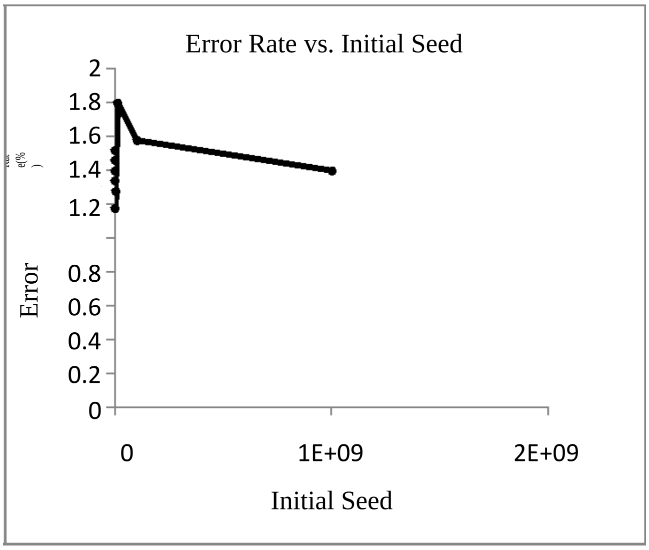

Fig. 9 signal to noise ratio vs. Initial seed

3) Signal to noise vs. E_b/N_0

Fig. 10 shows the significance of E_b/N_0 (dB) to the Error Rate of QAM system in more detail. E_b/N_0 directly related to the Signal to Noise Ratio and to design a QAM system it is also possible to choose E_b/N_0 to the required Error Rate in an alternative way in place of Signal to Noise Ratio.

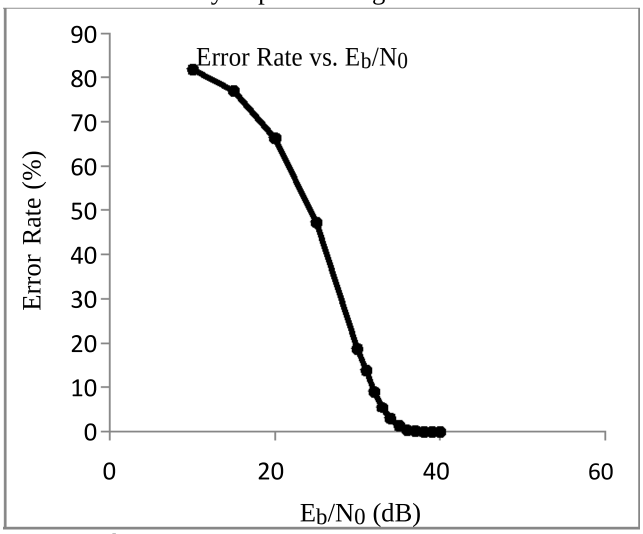

Fig. 10 signal to noise ratio vs. E_b/N_0

IV. CONCLUSION

This paper reports on the detailed analysis of Quadrature Amplitude Modulation Transmitter and Receiver system under varying channel condition. This paper explores the appropriate Error Rate and Signal to Noise Ratio values for design point of view.

Performance analysis helps designer to choose appropriate values of all the quality parameters by the help of corresponding graph(s).

REFERENCES

[1] Manjeet S. Patterh, T. S. Kamal and B. S. Sohi, *"Performance ofCoherent Square MQAM with Lth order Diversity in Rician Fading Environment"* IEEE vol. 6, pp. 2849-2853 Sep. 2000.

[2] S. Haykin, *Communication Sysrems,* New York: john Wiley & sons, 1978.

[3] A. H. Aghvami, 0. Gemikonakli and S. Kato, *"Transmission ofSDH signals through future satellite channels using high level modulation techniques,"* IEEE *JSelect. Areas commun.,* vol. 10,pp. 1030-1036, Aug. 1992.

[4] J. Pelton, and W. W. Wu, *"The chanllenge of 21'' century satellitecommunications: INTELSAT enters the second millennium,''* IEEE *JSelect. Areas commun..* vol. *5,* pp. 571-591, May 1987.

[5] T. Eng, N. Kong, L. B. Milstein, *"Comparison of diversitycombining techniques for Rayleigh-fading channels,"* IEEE *Trans. Commun.,* vol. 44, 11 17 - 1129, Sept. 1996.

[6] M. schwartz, W. R. Bennett, and S. Stein, *CommunicationSysrems and Techniques,* New York: McGraw-Hill, 1966.

[7] E. K. AI - Hussaini and A. A. M. AI - Bassiouni, *"Performance ofMRC diversity systems for the detection of signals with Nakagami fading,"* IEEE *Trans. Commun.,* vol. 33, 1315 - 1319, Dec. 1985.