BER Improvement of BPSK, QPSK and GMSK in Rayleigh fading channel

Atul Gautam, Kumar Saurabh, Manisha Sharma

ABSTRACT:

In this paper BER performance of communication system with using different modulation techniques i.e. BPSK, QPSK and GMSK in Rayleigh Fading Channel is enhanced by using LPDC encoder. Low density parity check (LDPC) codes are one of the best error correcting codes in today's coding world and are known to approach the Shannon limit. As with all other channel coding schemes, LDPC codes add redundancy to the uncoded input data to make it more immune to channel impairments. The choice of digital modulation scheme will significantly affect the characteristics and performance and resulting physical realization of a communication system. In order to choose the most suitable modulation have several criteria such as power efficiency and bandwidth efficiency and bit error rate are used for evaluation. We have describes the new combined method that consists of a cooperative approach of several different algorithms for improve the performance of system i.e. reducing BER.

Keywords: BPSK, QPSK, GMSK, BER, SNR, LPDC and spectral efficiency.

I. INTRODUCTION:

The growing demands for voice and multimedia services on mobile wireless communication spur the advancement of the wireless communication field in the recent decade. And one of the major technologies is the digital modulation technique which allows digitized data to be carried or transmitted via the analog radio frequency (RF) channels. Digital modulation techniques contribute to the evolution of our mobile wireless communications by increasing the capacity and speed as well as the quality of the wireless network. The design of a communication system is application oriented and is dependent on the type of the signal. And the choice of digital communication technique over its analog counterpart becomes more evident of the fact that it provide larger immunity to noise for even at the price of large bandwidth requirements and where as the requirement of video or Audio and data over the computer network or the mobile telephony network termed as the third generation (3G) mobile communication poses a serious problem for the bandwidth so The existing modulation techniques need to be modified for the purpose where it can handle both the situations of noise and bandwidth efficiency

This paper concentrates on PSK modulation techniques in which a finite number of phases are used to represent digital data. This paper concentrates on PSK modulation techniques in which a finite number of phases are used to represent digital data. The digital modulation schemes have greater capacity to convey large amounts of information than analog modulation schemes. In any phase modulation scheme the information is expressed in terms of phase of the carrier. And phase of the carrier signal is shifted according to the input binary data. Two-state phase shift keying (PSK) is called BPSK where the phase of the radio carrier is set to 0 or π according to the value of the incoming bit and each bit of the digital signal produces a transmit symbol with duration Ts which is equal to the bit duration Tb. Four state or quadric phase PSK is called QPSK in which two bits are combined and the radio carrier is phase-modulated according to the four possible patterns of two bits. Therefore transmitting a symbol takes twice as long as a bit ($Ts = 2\cdot Tb$) which means that the bandwidth efficiency of QPSK is twice that of BPSK. Gaussian Minimum Shift Keying (GMSK) is a spectrum and power efficient modulation scheme, used in many wireless communication systems. The main disadvantage of MSK is that it has inward side lobe. As a modulation scheme with better spectral properties was needed for mobile communication, GMSK was proposed by Morata and Hirate in 1979. The key idea is to vary the bandwidth of Gaussian pre modulation filter such that a compact power spectrum with suppressed side lobe can be achieved by pulse shaping at the sacrifice of introducing some ISI.

Here we have the multipath Rayleigh fading channel for complex baseband channel. Since signal propagation takes place in the atmosphere and near the ground apart from insignificant effect of free path loss and the most notable effect of signal degradation is multipath propagation. And the effect can cause fluctuations in the received signal's amplitude and phase and angle of arrival and giving rise to terminology multipath fading Accurate BER performance evaluation is crucial for the successful design and fine tuning of a digital communications system. In many cases, exact BER expressions either do not exist or they are too complex to be of any practical value. So to reduce the BER of the system we use better encoding scheme which detect error and correct it. Therefore to solve this problem we use LPDC encoder with different modulation techniques i.e. BPSK, QPSK and GMSK.

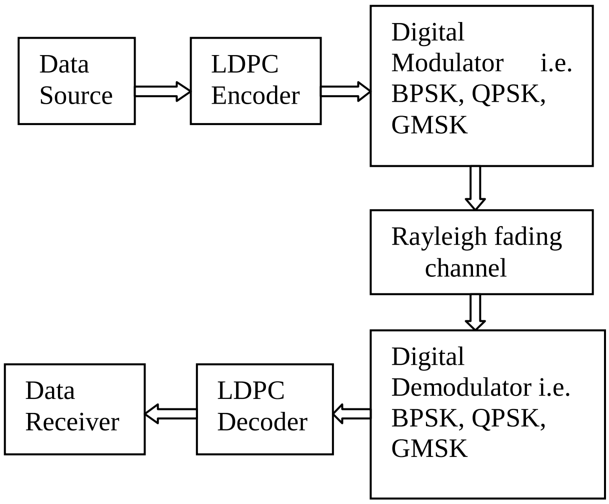
As stated above, channel coding ads redundancy to the uncoded signal and thus increases the bandwidth in the process. So, a modulation technique is needed which is spectrally efficient and also has good error performance. Therefore much research has been done on the concatenation of LDPC codes with different modulation techniques. Also, the earlier studies reveal that uncoded signal has error in the performance of system. Therefore we needs to be established is whether to use BPSK, QPSK or GMSK with channel coding, specifically LDPC codes to remove error from the signal.

This paper is organized as follows. Section II gives an overview of the system model. In section III, LDPC codes are presented. Digital modulation is discussed in Section IV. The fading model used is described in Section V. The simulation details are given in section VI. Finally, in section VII, the simulation results and conclusion are presented.

II. SYSTEM MODEL:

In this section we describe communication system model. The system model used is shown in Fig. 1. The data to be transmitted over the channel was randomly generated and was in the uncoded form. This data is coded by using LDPC codes. After the coded bit sequence has been obtained, it is applied to digital modulator which may be BPSK, QPSK and GMSK modulation techniques. This modulated waveform is transmitted over the Rayleigh fading channel in the presence of AWGN (Additive White Gaussian Noise). The received signal is passed through demodulator and LPDC decoder where the errors are detected and corrected. After that we analyze that how much BER reduces by using LPDC encoder with different modulation techniques. BER reduces then the performance is good and gets better result than the previous result.

The various blocks used in the model have been described in detail below.



III. LDPC CODE

Low density parity check (LDPC) codes were developed by Robert Gallager in his Ph.D thesis at MIT in 1962. In 2001, T.J Richardson, A. Shokrollahi, and R. Urbanke proved that the performance of LDPC codes is close to the Shannon limit (the limit of reliable communication over unreliable channels). It has been further demonstrated by simulations that LDPC codes of block length 10^7 approach the Shannon limit within 0.0045dB. Because of their excellent forward error correction properties, LDPC codes are set to be used as a standard in Digital Video Broadcasting (DVB-S2) and 4G mobile communication. Another advantage of LDPC codes is that they are highly parallelizable in hardware. Also, their minimum distance (dmin) increases proportionally with an increase in the block length. As the name suggests, LDPC codes are characterized by a parity check matrix which is sparse. A sparse matrix is one in which the number of 1's is very less as compared to the number of 0's. Due to the sparse property of the matrix, the size of the matrix can be increased without an increase in the number of 1's, which means that we can achieve better distance properties without increasing the decoding complexity. The LDPC codes are represented graphically by Tanner graphs in which there are two types of nodes, check nodes and bit nodes [15]. In order to prove that some mathematically result about Low Density Pair Check code, the channel model considered here are called symmetric binary input channel. By this we mean a time discrete channel, for which the input is a sequence of binary digits 0 and 1, and the output is corresponding sequence of letter from a discrete or continues alphabet.

Here define the rate R of such codes and if code word of length n. then there are 2^{nR} possible sequence from the source that are mapped into n-length code words. Thus only a fraction $2^{-n(1-R)}$ of different n-length sequence can be used as code words.

At the receiver, the decoder with its knowledge of which sequence are code words can seprate the transmitted n-length code words from the channel noise. Thus the code words are mapped back into the nR information digits.

The decoding scheme described in LPDC avoids the intermediate decision and operate directly with a posteriori probability of input symbol conditionals on the corresponding received symbol. The code described here with special example of parity check codes. The code words of parity-check code are formed by combining a block of binary information digits with block of check digit. Each check digit is the module 2 sum of a pre-specified set of information digits.

These formation rules for the check digits can be represented conveniently by parity check matrix, as shown in equation 1. The matrix represents a set of linear homogeneous module 2 equations called parity-check equations and set of code words is a set of solutions of this equation. We call the set of digits contained in a parity check equation a parity check set. And for example the first parity check set in equation 1 is the set of digits.

$$n(1-R)\begin{bmatrix} 1 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$$

(1)

The use of parity check code makes coding relatively simple implement. Also if a typical parity check code of long block length is used on a BSC, and if the code rate is between critical rate and channel capacity then probability of decoding error will be almost as small as that for best possible code of that rate and block length.

Low Density Pair Check codes are codes specified of matrix containing mostly 0’s and relatively flow 1’s. In particular, an (n, j, k) low density code is a code of block length n with matrix like that in equation 1, where each column contain a small fixed number j of 1’s and each row contain a small fixed number k of 1’s. This type of matrix has the check digit appearing in diagonal form as in equation 1.

IV. DIGITAL MODULATIONS:

Modulation is the process by which signal waveforms are transformed and enabled to better withstand the channel impairments. The three digital modulation techniques which dominate analog modulation are BPSK (Binary Phase Shift Keying), QPSK (Quadrature Phase Shift Keying) and GMSK (Gaussian Minimum Shift Keying). When the phase of the carrier wave is altered with reference of the modulating signal then the resultant modulation scheme is termed as Phase Shift Keying. The digital modulation technique can be said to be the simplest form of phase modulation and is known as binary because the carrier phase represents only two phase states. It is normally used for high speed data transfer application, provides a 3dB power advantage over the BASK modulation technique and is robust and simple in implementation but proves to be an inefficient user of the provided bandwidth and is normally termed as a non-linear modulation scheme. And it provides small error rates than any other systems. The mathematically representation of BPSK signal is

$$V_{BPSK}(t) = b(t)\times\sqrt{2}.P_s \cos(2\pi f_c t) \qquad (2)$$

Here b (t) = ± 1

QPSK is one example of M-ary PSK modulation technique (M = 4) where it transmits 2 bits per symbol. The carrier phase takes on one of four equally spaced values; such as 0 π/2 π and 3π/2 where each value of phase corresponds to a unique pair of message bits. Therefore basic signal for QPSK can be expressed as

$$V_{QPSK} = \left\{\sqrt{E_s}\cos\left[(i-1)\frac{\pi}{2}\right]\emptyset_1 - \sqrt{E_s}\sin\left[(i-1)\frac{\pi}{2}\right]\emptyset_2\right\}$$

(3)

Special characteristics of QPSK are twice data can be sent in the same bandwidth compared to Binary PSK (BPSK) and QPSK has identical bit error probability to that of BPSK. When QPSK is compared to that of BPSK and QPSK provides twice the spectral efficiency with the same energy efficiency. Furthermore, similar to BPSK, QPSK can be differentially encoded to allow non coherent detection. Due to these advantages of QPSK, it has been employed as modulation techniques in UMTS and 3G wireless networks.

An MSK signal is generated by applying a half sinusoidal pulse in place of a square pulse. If a Gaussian pulse shape is used instead then the resultant digital modulation technique is an improved version of the MSK digital modulation technique in the sense of bandwidth and spectral efficiency and is termed as GMSK digital modulation technique (Gaussian Minimum Shift Keying). Moreover, the major advantage in this technique is the sufficiently lower side lobe levels and the narrower main lobe as compared to a QPSK. GMSK can be viewed as either a frequency or phase modulation scheme, although the rate of change of phase is limited by the Gaussian response but he phase carrier can still advance or retard up to 90o over the course of the bit period. Therefore the severity in pulse shaping lies on the bandwidth time product (BT) because of the reason that the achieved phase change over a bit period may fall short by π/2 which will have a severe impact on bit error rate but it still provides improved bandwidth efficiency over QPSK. The bandwidth of a GMSK system is defined by the relationship between the pre modulation filter bandwidth B and the bit period TB. Thus the decision of value of BT and data rate is crucial in the sense that there has to be a trade of between the BER and out of band interference as the narrow filter will result in provocation of Inter Symbol Interference (ISI) which on the other hand will reduce the signal power enormously. The GSM standards use GMSK as their modulation scheme with BT product equal to 0.3. The impulse response of the Gaussian filter is:

$$g(t) = \frac{1}{2T}\left[Q\left(2\pi D_b{}^{t-\frac{t}{2}}\sqrt{\ln 2}\right) - Q(2\pi D_b{}^{t+t/2}\sqrt{\ln 2})\right]$$

(4)

Where Q (t) is the function

$$Q(t) = \int_t \frac{1}{\sqrt{2}} exp\frac{x^2}{2}dx$$

(5)

B_b is bandwidth of the low pass filter having a Gaussian shaped spectrum, T is the bit period and B_bT is the normalized bandwidth.

V. RAYLEIGH FADING:

In wireless telecommunications, the multipath is the propagation phenomenon that results in radio signals reaching the receiving antenna by two or more paths. It is a statistical model for the effect of a propagation environment on a radio signal such as that used by wireless devices. And Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly or fade according to a Rayleigh distribution. Therefore Rayleigh fading is most applicable when there is no dominant propagation along a line of sight between the transmitter and receiver. In this section; examine the impact of movement on the mobile receiver (or transmitter) causes on the received signal. Causes of multipath include atmospheric ducting, ionosphere reflection and refraction, and reflection from water bodies and terrestrial objects such as mountains and buildings. Then the effect of multipath contains constructive and destructive interference; and phase shifting of the signal. It is the main causes Rayleigh fading. Then standard statistical model of this gives a distribution known as the Rayleigh distribution. Rayleigh fading channel known; when there is no direct component, and all signals reaching the receiver are reflected. Mathematically the multipath Rayleigh fading of wireless channel modeled by the channel impulse response (CIR) is given below.

$$h(t) = \sum_{l=0}^{Lp-1} \alpha_l \partial(t - \tau_l)$$

(6)

Where, Lp is the number of channel paths, α_l and τ_l are the complex value and delay of path l, respectively. The paths are assumed to be statistically independent, with normalized average power. The channel is variant with time due to the motion of the mobile terminal, but we will assume that the CIR is constant during one OFDM symbol. Generally, two fading effects in mobile communications: large-scale and small-scale fading. Firstly large-scale fading represents the average signal power attenuation or path loss due to shadowing effects when moving over large areas. Another hand; small-scale fading refers to the dramatic changes in signal amplitude and phase that can be experienced as a result of small changes (as small as a half-wavelength) in the spatial separation between a receiver and transmitter.

VI. SIMULATION DETAIL

In this paper, the performance of coded BPSK, QPSK and coded GMSK is compared with each other and with their uncoded counterparts over Rayleigh fading channel. The length of the coded bit stream was taken to be 600. The bandwidth-time (BT) product for GMSK is 0.25 and the oversampling period is 8. The number of iterations is taken to be 1000. Thus the channel is modeled as Rayleigh fading and the complex noise is added randomly. The path amplitudes in Rayleigh i fading were taken to be Rayleigh distributed. Unless otherwise stated, it is assumed that:

1. The Rayleigh fading model that we use in our simulations is not flat.

2. The B_bT product of the pre modulation Gaussian filter in GMSK is always taken to be 0.25. 3. The receiver has complete knowledge about the channel.

VII. SIMULATION RESULT AND DISCUSSION

Many simulation runs have been done for BPSK, QPSK and GMSK in code and uncoded format for different values of m. But this time we do simulation with LPDC encoder to reduce BER with different modulation techniques i.e. BPSK; QPSK and GMSK. The obtained results are presented in the following figures. From given below figure 2 we analyze that by using LPDC encoder and all the three modulation technique i.e. BPSK, QPSK and GMSK in Rayleigh fading channel reduce BER to the sufficient value which enhances the system performance under Rayleigh channel. At instantaneous SNR value; the BER value below the 10^{-1}. As SNR increases three modulation techniques BER value reduces. And we find that LPDC encoder performance is good with BPSK and QPSK. But in case of GMSK we cannot reduce the BER rate to sufficient value. Because in GMSK; the data is much more than BPSK and QPSK. Therefore the value BER does not reduce to appropriate value.

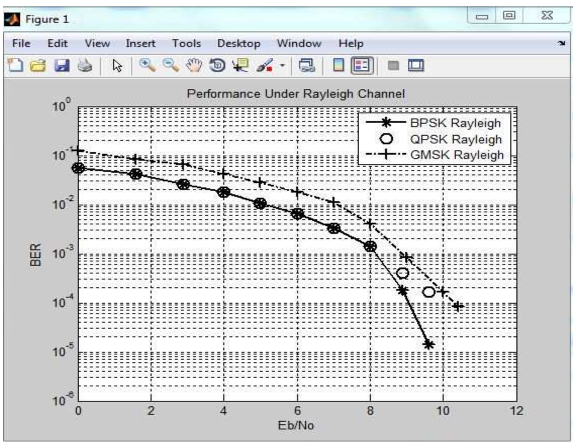


Figure 2: A comparison graph for Rayleigh channel for BPSK, QPSK & GMSK transmission schemes

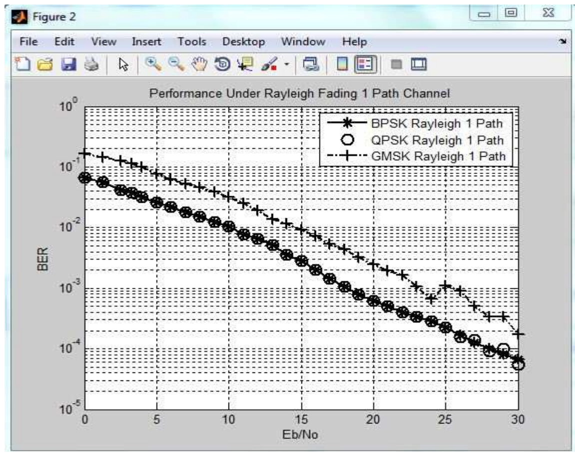


Figure 3: A comparison graph for 1-path Rayleigh channel for BPSK; QPSK & GMSK transmission schemes.

Here we compare three modulation techniques under 1-path Rayleigh channel. And we get better result than previous result by using LPDC encoder. At SNR=30, our BER value reduces below to the 10^{-4} which better than our previous result. Here we get better BPSK modulation result equal to the QPSK modulation result.

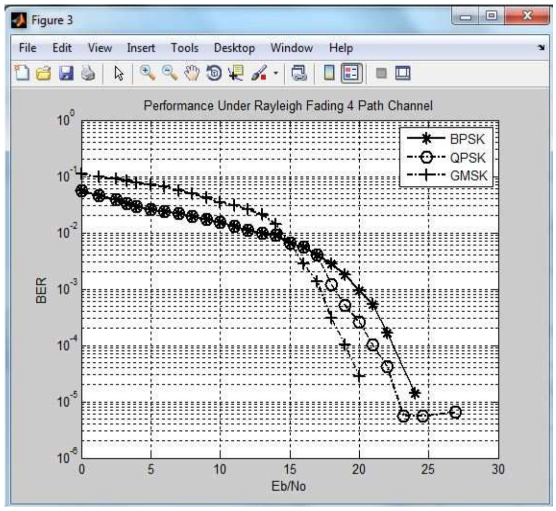


Figure 4.3: A comparison graph for 4-path Rayleigh channel for BPSK, QPSK & GMSK transmission schemes

BPSK and QPSK obtained similar result with BPSK requiring less signal power to obtain a 0 BER than QPSK. But as our E_b/N_0 increase the QPSK BER value reduces much more than BPSK BER value. GMSK BER performance is slightly higher than BPSK/QPSK and at higher E b/N 0 the BER is slower than both BPSK and QPSK[17]. This might the reason why GMSK is chosen to be the standard in GSM or it might due to the inaccuracy of the simulation program.

Therefore at last we analyze that LPDC encoder gives better result with all three different modulation techniques i.e. BPSK, QPSK and GMSK in Rayleigh fading channel.

VIII. CONCLUSION

It is concluded that the overall performance of LDPC coded BPSK, QPSK and coded GMSK is better than simply coded. Even though a slightly better BER was obtained by using LPDC. GMSK is spectrally efficient and ideal to use with LDPC codes as the latter introduces redundancy that leads to spectral widening. The use of GMSK with LDPC codes ensures the efficient use of the spectrum when number of channel increases. The main purpose of this paper has been to present the commonly used modulation schemes in satellite communication systems and demonstrate the performance of PSK modulated systems in the presence of a noisy channel along with the ways to reduce the BER

REFERENCES

[1] Singh, Simranjit. Sharma, Surbhi. And Khanna, Rajesh.(2009) "Performance of Uncoded and LDPC Coded MSK and GMSK in Nakagami Fading" International Journal of Recent Trends in Engineering, Vol 2, No. 6.

[2] Masud M, A. Samsuzzaman ,M. and Rahman, M A.(2010) "Bit Error Rate Performance Analysis on Modulation Techniques of Wideband Code Division Multiple Access", Journal of Telecommunications .

[3] Wu, Feng. and Yu, Peiwen.(2010) "Theoretically Optimal Low-Density Parity-Check Code Ensemble for Gallager's Decoding Algorithm A" 2010 Data Compression Conference.

[4] Sharma, D.K. Mishra, A. And Saxena, Rajiv.(2010) "Analog & Digital Modulation Techniques: An Overview" International Journal of Computing Science and Communication Technologies, VOL. 3, NO. 1, (ISSN 0974-3375)

[5] Kaur, Harjot. Jain, Bindiya. And Verma, Amit (2011) "Comparative Performance Analysis of M-ary PSK Modulation Schemes using Simulink" IJECT Vol. 2, Issue 3.

[6] Chauhan, Vikas. Arora, Manoj. and R. S. Chauhan (2011) "Comparative BER Performance of PSK based modulation Techniques under Multipath Fading" Advances in Applied Science Research, 2011, 2 (4):521-527

[7] Gupta, Megha. Prof. Nema, Rajesh. Dr. Mishra, Ravi Shankar. and Dr. Gour, Puran. (2011) "Bit Error Rate Performance in OFDM System Using MMSE & MLSE Equalizer Over Rayleigh Fading Channel Through The BPSK, QPSK,4 QAM & 16 QAM Modulation Technique" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622. Vol. 1, Issue 3, pp.1005-1011

[8] Dahlman, Erik. Gudmundson, Bjorn. Nilsson, Matts. and Skold, Johan.(2011) "UMTS/IMT-2000 Based on Wideband CDMA", IEEE Communications Magazine

[9] Varade, Suchita. and Kulat, Kishore. (2012) "BER Comparison of Rayleigh Fading, Rician Fading and AWGN Channel using Chaotic Communication based MIMO-OFDM System" International Journal of Soft Computing and Engineering (IJSCE) ISSN: 2231-2307, Volume-1, Issue-6.

[10] Beheshti, B. Jalali, M. Lotfi, M. and Ghand, S. (2012) "A New Low-Power Noncoherent BPSK Demodulator for Biomedical Applications" IEEE-VLSI-SoC2012 Proc., 2012, Santa Cruz, USA

[11] Prof. Nemade, Sandip. Rajneesh. And Neha (2012) "Performance of 2:1 MISO System for M-QAM Under Rayleigh and RICIAN Channels" International Journal of Electronics Communication and Computer Engineering Volume 3, Issue 6, ISSN (Online): 2249–071X, ISSN (Print): 2278–4209

[12] Prof. Dua, Rajeshwar Lal. and Yadav, Pooja.(2012) "BER Analysis with OFDM using PSK/QAM Techniques for Wireless Communication" International Journal of Engineering Research & Technology (IJERT)Vol. 1 Issue 7, ISSN: 2278-0181

[13] Adsul, Alpana P. and Dr. Bodhde,S.K.(2012) " Performance Comparison of BPSK, PPM and PPV Modulation Based IR-UWB Receiver Using Wide Band LNA." ,Int. J. Computer Technology & Applications, Vol. 3 (4), 1532-1537

[14] Adeyemo, Zachaeus K. Aborisade, David O. and Abolade, Robert O. (2012) "Performance of GMSK in Mobile Satellite Communication Channel with Orthogonal Frequency Division Multiplexing" European Journal of Scientific Research ISSN 1450-216X Vol. 89 No 1, pp.32-41.

[15] Kaur, Baljit. (2013) "Interleaver Based Design of LDPC Coder Using CPM Techniques for DVB-S2" VSRD International journal of electrical, electronics &communication Engineering, Vol. 3 No. 1, ISSN No. 2231-3346

[16] Gautam, Atul. and Sharma,Manisha.(2013) "Capacity Enhancement of MIMO-OFDM System in Rayleigh Fading Channel" IOSR Journal of Electronics and Communication Engineering (IOSR-JECE) e-ISSN: 2278-2834,p- ISSN: 2278-8735. Volume 6, Issue 1, PP 49-58.

[17] Brindha, G.(2013) "Performance Analysis Of MC-CDMA System Using BPSK Modulation" International Journal of Research in Engineering & Technology (IJRET) Vol. 1, Issue 1, 45-52

.