ADAPTIVE MODULATION USING OFDM COMMUNICATION SYSTEM FOR SOFTWARE DEFINED RADIO

[1]Rajesh R. Bhambare, [2]Dr. Rajeshree D. Raut
[1]Associate Professor, [2]Professor & Head
[1]Electronics Engineering Department,
[1]Pravara Rural Engineering College, Loni, India
[2]Electronics Design Technology Department
[2]Ramdeobaba College of Engineering and Management, Nagpur, India

Abstract: Adaptive modulation is a technique in which power and number of bits per subcarrier are allocated to the amplitude response of the frequency selective fading channels for better performance involving high data rate transmission. The performance of adaptive OFDM techniques with discrete rate M-ary quadrature modulation (M-QAM) in frequency selective fading channels is analyzed in this paper. The adaptive modulation schemes are used here for constant power constraints and giving higher spectral efficiency for given target bit error rate (BER). The antenna selection and dynamic adaptive modulation can greatly improve the performance of adaptive modulator for SDR.

Index Terms **–Adaptive modulation, BER, Software defined Radio, OFDM**

I. INTRODUCTION

The orthogonal frequency modulation (OFDM) represents a multicarrier modulation method used to solve limitations related with high bit rate transmission. Time dispersion does maximum degradation in OFDM transmission. The multiple lower –rate streams are formed from original data carrying symbol stream. The multiple streams are modulated on different carriers. The number of carriers which are orthogonal to each other results in higher symbol duration. Due to this only a small portion of adjacent symbols get affected by multipath echoes. The cyclic prefix (CP) is used to remove the remaining intersymbol interference.

The emergence of new technologies and increasing number of wireless devices has made radio spectrum increasingly occupied. The orthogonal frequency modulation technique along with adaptive modulation integrates spatial, temporal and spectral components together. The channel fading is the major lacuna of wireless communication systems. Deep fading results in errors if fixed mode modulation technique is used. The feedback channels are used to give the channel state information at receiver back to transmitter. The modulation techniques and / or channel coding format with other OFDM parameters are adaptively changed to minimize the major degradation caused due to deep fades.

In our communication scheme, we are using variations of QAM for changing the modulation type of our system. In this paper, the next section describes various schemes used by researchers for adaptive modulation for SDR, and their comparative analysis. Section III describes our proposed dynamic adaptive modulation algorithm, and antenna diversity based dynamic adaptive modulation. Section IV elaborates the system model. Section V compares the results of our proposed algorithm.

II. LITERATURE REVIEW

In [1] Adrian Tarniceriu et al. have shown the Features of modulation techniques and estimated the figure of merit for each particular modulation for SDR. The wireless standard IEEE 802.16, WI MAX is used for analysis. Modulation techniques like QPSK, QAM-16 and QAM-64 on OFDMA carrier support are used. Transmitter and receiver are considered ideal and Additive white Gaussian noise is inserted in channel. The maximum transmitted power is kept constant, for each type of modulation. It shows that higher SNR are needed to demodulate the signal within the target BER as the modulation number of bits per symbol increases.

Hanzo et al. [2-4], proposed adaptive modulation schemes working on set of mode switching threshold levels designed to obtain high average bits per second (BPS) throughput, while keeping the target BER of the system at particular level.

In [5] Czylwik showed that by optimizing Power only 1 db power gain is achieved. Hence it is recommended to use constant power spectrum and not to have optimization of power distribution. It saves computational complexity. In adaptive OFDM (knowing instantaneous state of sub channel) appropriate numbers of bits are allocated and proper modulation method is selected for transmission in each subcarrier. The objective is to improve the system performance or to keep the overall bit error rate at a particular level.

In [6] Muhamad Islam et al. have shown the model of the transceiver in Matlab and BPSK transmitter is used along with Additive white Gaussian noise (AWGN) channel and BPSK receiver. The PSK modulation scheme for SDR is suggested to select the constellation size that offers the best reconstructed signal quality for each average SNR. The audio signal transmission quality is evaluated and the performance of the linear modulation is compared.

In [7] Sami H.O. Salih et al. have shown implementation of adaptive modulation and coding technique using Matlab. The various digital modulations combined with different coding techniques, giving higher throughput and better spectral efficiency by sending more bits per symbol.

In [8] Michel Borgne explained a comparative analysis of various forms of QAM techniques. The effects of filtering, interference, amplifier nonlinearities and selective fading are studied. The spectral efficiency of QAM is good but it is complex to implement. The nonlinearities and selective fading are major issues with these schemes. Nonlinearity cancellers and adaptive equalizers are required in such systems. For good BER, strong signal strength is required. It is also bandwidth efficient. For higher modulation schemes like 64QAM, 256 QAM higher SNR is needed.

To reduce the effect of multipath fading [10] antenna diversity is efficiently used in most scattering environments. The quality of the received signal is improved by using multiple antennas at the receiver and Performing combination or selection and switching. The main problem in using the receive diversity approach is costly and bulky system and power of the remote units. It is useful in designing base stations improving their reception quality.

III. ADAPTIVE OFDM

The power and number of bits per subcarrier can be allotted uniformly or by non-uniform way[9]. Each subcarrier can have same number of bits and equal power. In second case, bits and power can be varied in such a way to give minimum bit error rate. The frequency response of the channel decides the BER of OFDM system. In case of frequency selective fading channels, some sub channels are with deep fades while others with better signal transmission ability with less attenuation. The subcarriers having high attenuation are identified and removed from transmission. The subcarriers with better channel state are used to transmit maximum number of bits. It gives better spectral efficiency with minimum bit error rate. In this article we have proposed Dynamic Adaptive modulation technique for SDR. In case of static Adaptive Modulation, the switching threshold levels are fixed. It is designed while considering the worst case channel scenario. In case of dynamic adaptive modulation the switching thresholds are changed dynamically as per channel quality to give higher spectral efficiency at given target BER. The modulation types used in OFDM systems can vary from 2QAM, 4QAM, 16QAM, 64QAM, 256 QAM.

Table 1. Digital Modulation Techniques

Type	Bits per symbol	Symbol rate
2 QAM	1	1 x bit rate
4QAM	2	1/2 bit rate
16QAM	4	1/4 bit rate
64QAM	6	1/6 bit rate
256 QAM	8	1/8 bit rate

3.1 Static Adaptive OFDM

Algorithm 1: Static Adaptive OFDM algorithm

Input: Signal to Noise Ratio (snr) = 50 (Max.)

For different Modulation types:
M = [2, 4, 16, 64, 256]

Channels used for simulation are 1. Rayleigh 2. Rician 3. AWGN

Target BER Selection: 0.1, 0.01, 0.001

Step 1: Input: - Random Message
Step 2: for ss = 0: snr
Step 3: if (ss<41) then M=64
Step 4: if (ss<15) then M=16
Step 5: if (ss<8) then M=4
Step 6: if (ss<3) then M=2
Step 7: end
Step 8: Execute Static Adaptive Modulation with the calculated vale of "M"

The different modulation curves are plotted for various QAM-OFDM modulation techniques. From the plot of BER Vs SNR, the switching thresholds are obtained for each modulation technique.

Table 2: Switching thresholds for Static Adaptive Modulation

	Target BER = Tg		
Modulation Scheme	Tg = 0.1	Tg = 0.01	Tg = 0.001
	SNR = ss	SNR = ss	SNR = ss
256 QAM	ss>41	ss>41	ss>41
64 QAM	ss<41	ss<41	ss<41
16 QAM	ss<15	ss<18	ss<20
4 QAM	ss<8	ss<12	ss<14
2 QAM	ss<3	ss<6	ss<8

Algorithm 2: Dynamic Adaptive OFDM algorithm with added diversity

Input: Signal to Noise Ratio (snr) = 50 (Max.)
For different Modulation types :
M = [2, 4, 16, 64, 256]
Channels used for simulation are 1. Rayleigh 2. Rician 3. AWGN

Target BER Selection: 0.1, 0.01, 0.001

Step 1: Input: - Random Message
Step 2: for ss = 0: snr
Step 3: if (berstor (2, ss+1) < Tg) then M= 4
Step 4: if (berstor (3, ss+1) < Tg) then M= 16
Step 5: if (berstor (4, ss+1) < Tg) then M= 64
Step 6: if (berstor (5, ss+1) < Tg) then M= 256
Step 7: end
Step 8: Execute Dynamic Adaptive Modulation with added diversity using calculated vale of "M"

Algorithm 3: Dynamic Adaptive Modulation

Steps 1 to 7 are performed as above and Dynamic Adaptive Modulation is Executed using calculated vale of "M"

IV. SYSTEM MODEL

Fig. 1.0 shows the block diagram of the proposed adaptive OFDM system. The channel state information is fed back from the receiver to transmitter [10]. The perfect channel estimation and perfect feedback is assumed. The probability of error is minimized by antenna selection and Signal to noise ratio is maximized.

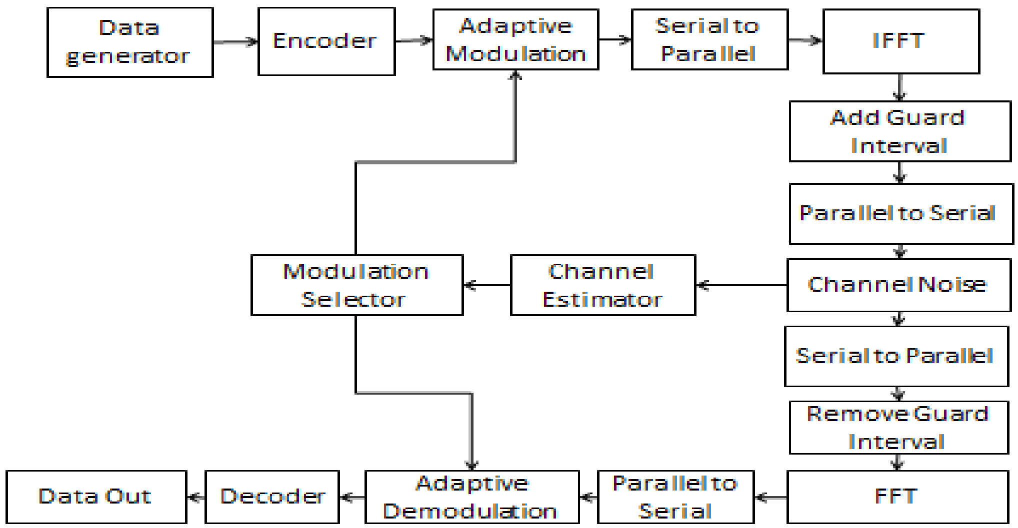

Fig. 1.0 Block diagram Adaptive OFDM System

The modulation selector selects the appropriate modulation scheme as per SNR vales given by channel state estimator. In this type of modulation the adaptive process is performed frame by frame. The various switching thresholds used for static adaptive modulation are shown in Table 2.0. It shows for SNR > 41dB, 256 QAM is used. For SNR < 41dB, 64 QAM is used. Similarly for SNR of15dB and 8 dB, 16 QAM and 4QAM modulation technique is selected. The static adaptive modulation thresholds are designed considering worst case channel performance, giving constant target BER required for particular service with reduced spectral efficiency.

4.1 The Proposed Dynamic adaptive modulation system: - It consists of dynamically changing switching thresholds as per channel quality. Here the look up table for switching thresholds is updated dynamically for every frame. The performance of Dynamic adaptive modulation system is better than static adaptive modulation system. It gives higher spectral efficiency than that of static adaptive modulation system.

4.2 The Proposed diversity added Dynamic adaptive modulation system: - It shows better performance as that of dynamic adaptive modulation system. It is useful in high voice quality and high data rate services in future mobile services. The antenna selection gives better throughput than that of without antenna selection

V. RESULTS AND DISCUSSION

Table 3.0 SNR and Modulation Scheme Variation, Target BER= 0.1 (Rayleigh Channel)

Dynamic ADM With Diversity		Dynamic Adaptive Modulation		Static Adaptive Modulation	
SNR dB	Modulation Order	SNR dB	Modulation Order	SNR dB	Modulation Order
0 to 11	2	0 to 11	2	0 to 2	2
12 to 17	4	12 to 17	4	3 to 7	4
18 to 26	64	18 to 22	16	8 to 14	16
27 to 50	256	24 to 26	64	15 to 40	64

		27 to 50	256	41 to 50	256

Table 4.0 SNR and Modulation Scheme Variation, Target BER= 0.1 (AWGN Channel)

Dynamic ADM With Diversity		Dynamic Adaptive Modulation		Static Adaptive Modulation	
SNR	Modulation Order	SNR	Modulation Order	SNR	Modulation Order
0 to 11	2	0 to 11	2	0 to 2	2
12 to 17	4	12 to 17	4	3 to 7	4
18 to 27	64	18 to 22	16	8 to 14	16
28 to 50	256	23 to 27	64	15 to 40	64
		28 to 50	256	41 to 50	256

Table 5.0 SNR and Modulation Scheme Variation, Target BER= 0.1 (RICIAN Channel)

Dynamic ADM With Diversity		Dynamic Adaptive Modulation		Static Adaptive Modulation	
SNR dB	Modulation Order	SNR dB	Modulation Order	SNR dB	Modulation Order
0 to 26	2	0 to 26	2	0 to 7	2
27 to 33	4	27 to 33	4	8 to 13	4
34 to 38	16	34 to 38	16	14 to 19	16
39 to 44	64	39 to 44	64	20 to 40	64
45 to 50	256	45 to 50	256	41 to 50	256

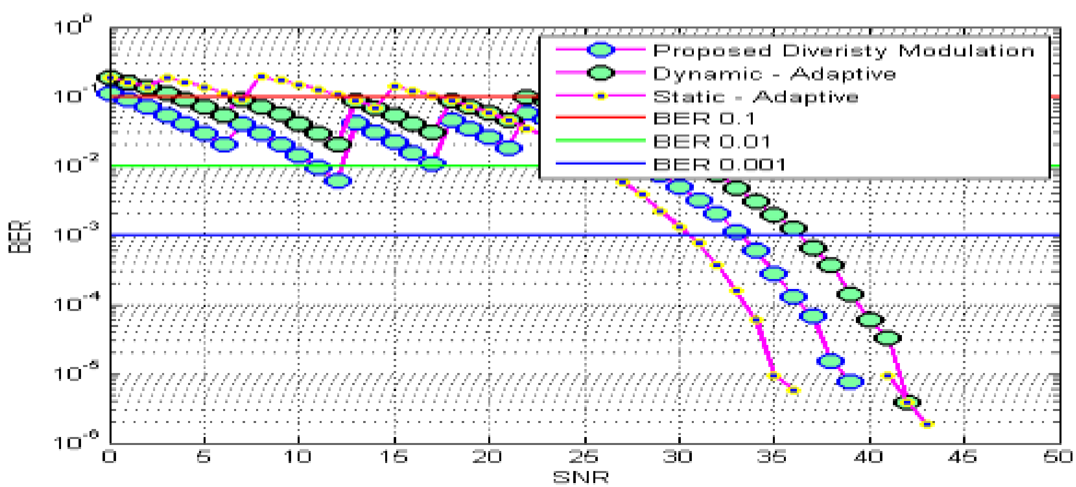

Fig 2.0 Graph of BER Vs SNR for Rayleigh channel at Target BER = 0.1

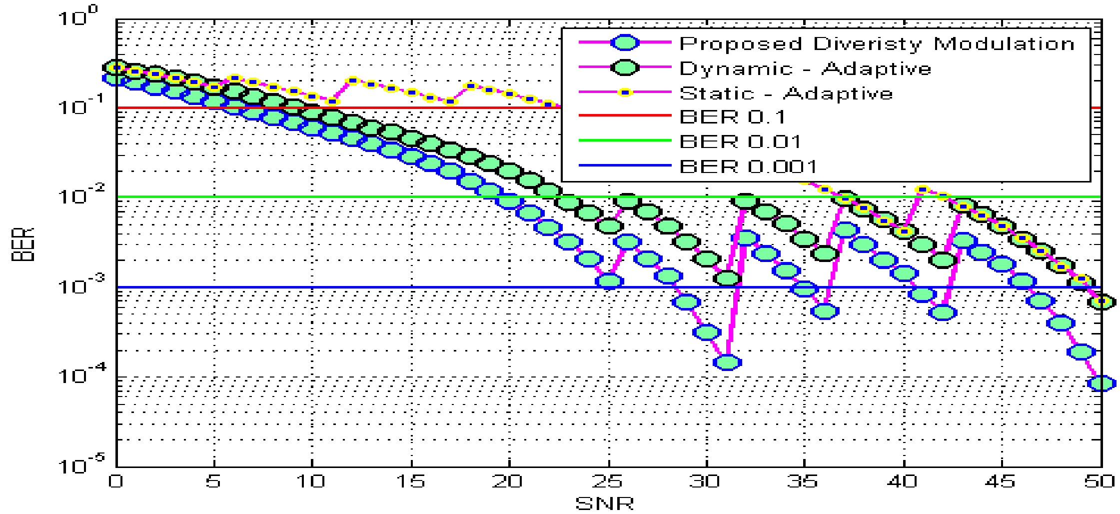

Fig 3.0 Graph of BER Vs SNR (dB) for Rayleigh channel at Target BER = 0.01

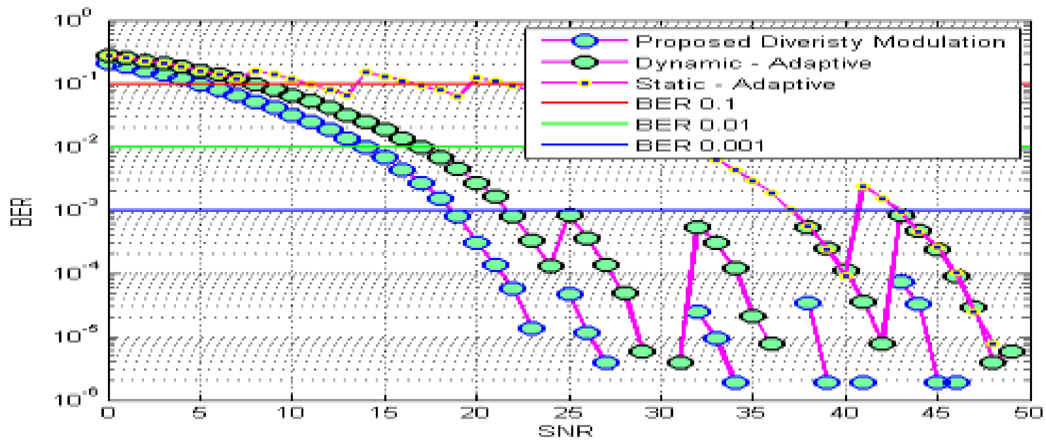

Fig 4.0 Graph of BER Vs SNR for Rayleigh channel at Target BER = 0.001

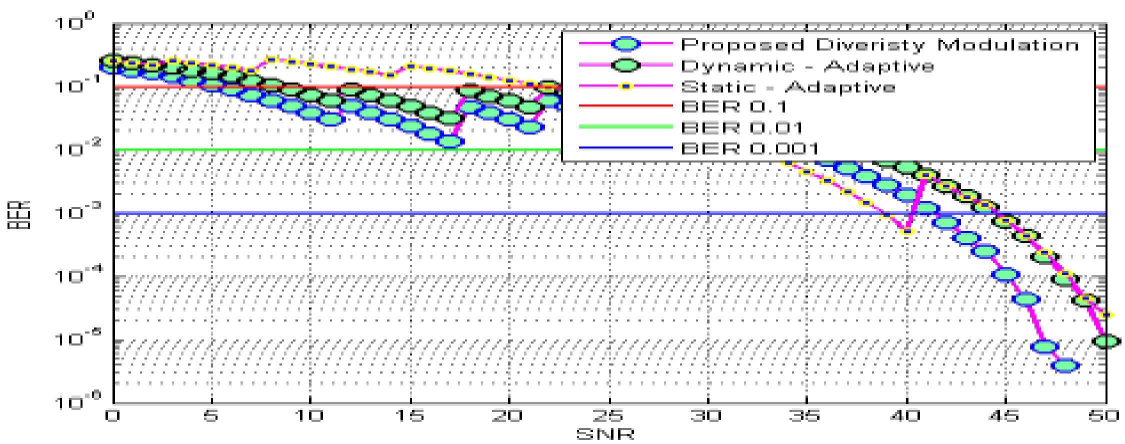

Fig 5.0 Graph of BER Vs SNR for Rician channel at Target BER = 0.1

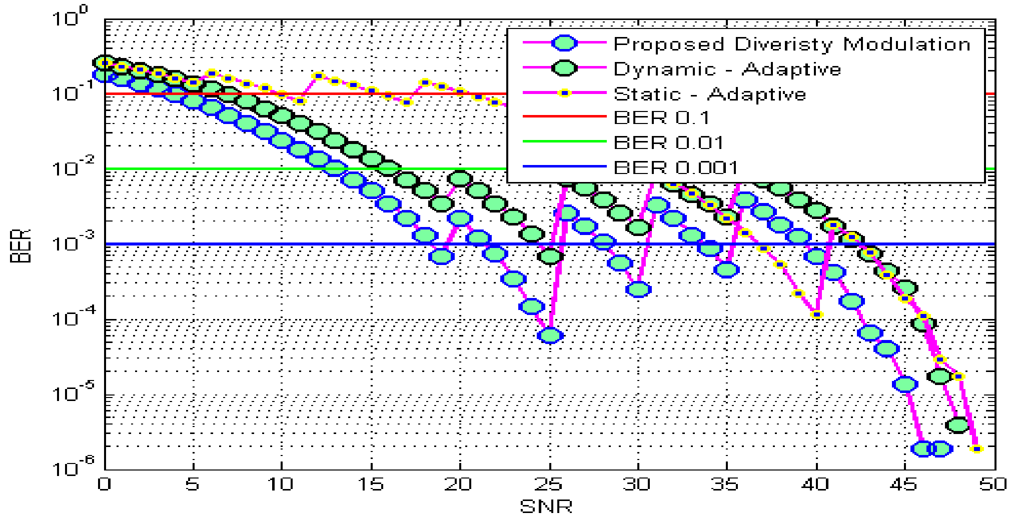

Fig 6.0 Graph of BER Vs SNR for Rician channel at Target BER = 0.01

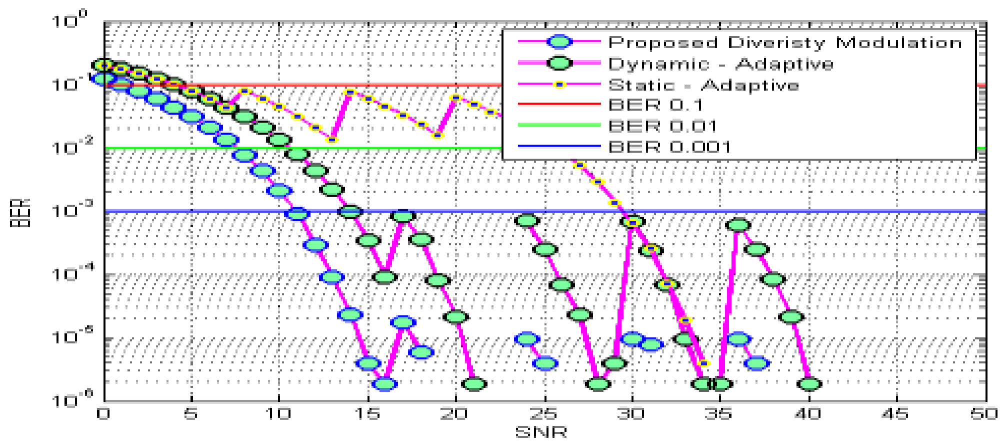

Fig 7.0 Graph of BER Vs SNR for Rician channel at Target BER = 0.001

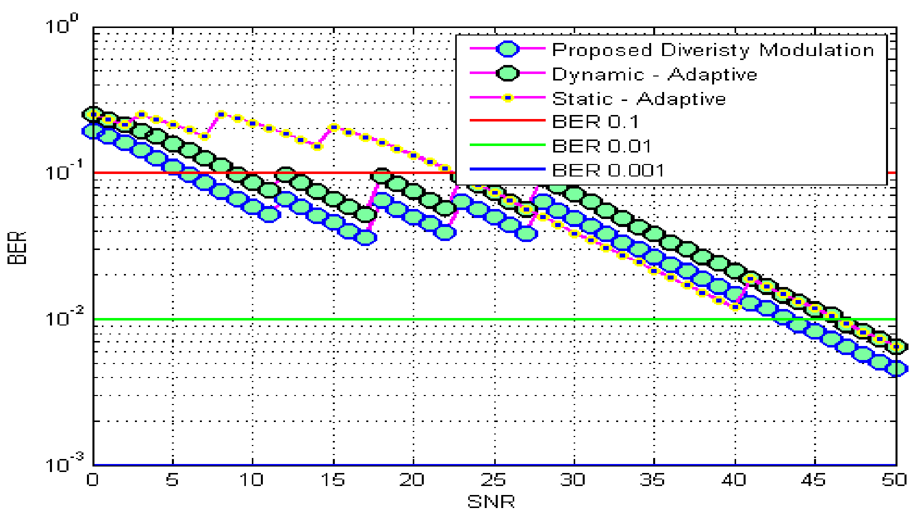

Fig 8.0 Graph of BER Vs SNR for AWGN channel at Target BER = 0.1

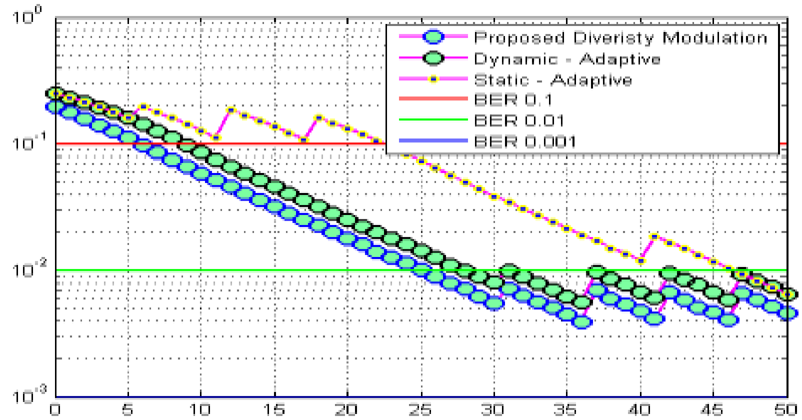

Fig 9.0 Graph of BER Vs SNR for AWGN channel at Target BER = 0.01

CONCLUSION:-

In this paper, a new scheme of Dynamic adaptive modulation system for SDR is presented. The proposed scheme shows better spectral efficiency for given target BER as compared to Static adaptive modulation system. The diversity added Dynamic adaptive modulation system for SDR shows higher spectral efficiency than that of Dynamic adaptive modulation system. The antenna selection boosts the performance of adaptive modulation system for SDR.

REFERENCES

[1] Aldrian Tarniceriu, Bogdan Iordache, "An Analysis on Digital Modulation Techniques for Software Defined Radio Applications", Semiconductor Conference, 2007.International CAS Oct. 15, 2007, Volume 2, pp.571-574

[2] Torrance J, Hanzo L. ,"Optimiization of switching levels of for adaptive modulation . In slow rayleigh fading channel.Electronics letters 1996:32:1167-9

[3] Chao BJ, Hanzo L. Optimum mode switching assisted adaptive modulation. In: Proceedings of IEEE global telecommunications conference (GLOBECOM'01), vol. 6, 2001, p. 3316-20

[4] Hanzo L, Web W Keller T, Single and multicarrier quadrature amplitude modulation. New York, USA: Wiley: 2000

[5] Czylwik A. Adaptive OFDM for wideband radio channels. In Proceedings of IEEE global telecommunication conference(GLOBECOM'01), vol. 6, 2001, p. 713-8

[6] Muhamad Islam, M. A. Hannan, S.A. Samed , A. Hussain, "Bit-Error-Rate for modulation technique using software defined Radio",International conference on electrical Engineering and Informatics,5-7August 2009,Malaysia,pp.445-447

[7] Sami H. O. Salih, Mamoun M. A. Suliman, "Implementation of adaptive modulation and coding technique using,"International Journal of Scientific & Engineering Research, Vol. 2, Issue 5, May-2011,pp.1-4

[8] Michel Borgne, "Comparison of high-level Modulation Schemes for High-Capacity Digital Radio Systems", IEEE Transactionson Communications, Volume, com-33,No. 5 May 1985

[9] Haitham J. Taha and MFM Salleh, "Multicarrier Transmission Techniques for wireless Communication Systems: A Servey, "Wesas Transaction on Communication," issue 5, Volume 8,May 2009,pp457-472

[10] Mohamed Al Wohaishi, Jan Zidek, Radek Martinek, "Analysis of M State Digitally Modulated Signals Communication Systems Based on SDR Concept", The 6th IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications 15-17 September 2011, Prague, Czech Republic

AUTHORS PROFILE

Mr. Rajesh R. Bhambare, born on April, 24th 1973, completed his bachelor's degree in Electronics Engineering, from Pravara Rural Engineering College, Loni M.S., India. He completed his Masters in Electronics from Jawaharlal Nehru Engineering College, Aurangabad in 2007. He is pursuing Ph.D in Electronics in the field of Optimized Adaptive Modulator for Software Defined Radio in Cognitive Environment. Having an experience of 20 years, he is currently working as an Associate Professor in Pravara Rural Engineering College, Loni, M.S., India. He has on his accord more than 18 International Journal and conference papers. He has published 1 Patent. He is the Life member of ISTE. He has organized ENSPIRE-2K13 a national level conference. His areas of interest are Cognitive Radio, Wireless Communication and Computer Networking. He has done M.B.A. in Marketing from Pune University M.B.A. Center, Pune in 1997.

Dr. Rajeshree Raut, Professor & Head Electronics Design Technology, RCOEM is a graduate(1998) and post graduate(2002) from Govt. college of Engineering, Amravati and has done her Ph. D in Error Control Coding in year 2011. She has 19 years of Teaching Experience and Industrial Experience of 1.5yrs. Her achievements include , ISTE National award for innovative Research in Engineering, 2017, ISTE National Award for Best Engineering teacher, 2013, RTM Nagpur University Best Teacher Award,2011, IIFS New Delhi, Shiksha Ratna Award, 2011, more than 65 Research publications having around 100 citations, H-index 6, i-10index 2, 3 patents published, 45 expert talks in Engineering Colleges at Nagpur, Pune, Raipur, Wardha, Nashik, Yeotmal, Aurangabad, Bhusawal, Ludhiyana, etc. She has also delivered expert talks and chaired International Conferences abroad in countries like Mexico, Dubai and Kualalampur, Malayasia. She is the Advisory and Editorial board member for many International Journals. She is currently guiding six research scholars. Three Research scholars have been awarded PhD under her guidance. She is the only and the first lady to represent ISTE Maharasthra & Goa Section, as SMC. She has authored a book on 'Error Control Coding; For Performance Improvement in Cognitive Radio', has been published by LAP Verlag Academic Publishing, on August 17, 2012. She has Written a book chapter in : Microelectronics, Electromagnetics and Telecommunications (ICMEET) 2015, Lecture Notes in Electrical Engineering (LNEE), Chapter No12, pp., 121-134, December 2015, Published by: Springer, ISBN: 978-81-322-2726-7. The Project guided by Dr. Raut, Tiled "DESIGN OF PSK SYSTEM IN COGNITIVE ENVIRONMEN", was awarded Best Engineering College Project, Award, for the Maharashtra state, Feb 2016 by ISTE. The sponsored projects successfully executed by her include projects from Amitec Electronics and Inotek Antennas Pvt. Ltd. She is well known personality for her work in Cognitive Radio Communications.