BER ANALYSIS OF MINIMUM AND MAXIMUM POWER ADAPTATION METHODS USING HAAR WAVELET IMAGE TRANSMISSION USING BPSK MODULATION

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ABSTRACT

This paper addresses power allocation methods for multimedia signals over wireless channels. The objective is to minimize total power allocated for image compression and transmission, while the power for each bit is kept at a predetermined value. Minimum and maximum power adaptation methods are proposed. In this work, an approach for minimizing the total power allocated of a multimedia like image due to source compression and transmission subject to a fixed bit source distortion. Simulations are performed using Haar wavelet over AWGN channel using BPSK modulation. The numerical analysis of Bit Error Rate (BER) shows that optimized power methods can reduce the total power allocated by a significant factor and the Bit error rate is reduced considerably compared to the Conventional power method using Haar wavelet..

KEYWORDS: *Minimum, Maximum, BPSK, Awgn, Haar Wavelet, Modulation*

I. INTRODUCTION

By the advent of multimedia communications and the information superhighway has given rise to an enormous demand on high-performance communication systems. Multimedia transmission of signals over wireless links is considered as one of the prime applications of future mobile radio communication systems. However, such applications require the use of relatively high data rates (in the Mbps range) compared to voice applications. With such requirement, it is very challenging to provide acceptable quality of services as measured by the bit error rate (BER) due to the limitations imposed by the wireless communication channels such as fading and multipath propagation. The main resources available to communications systems designers are power and bandwidth as well as system complexity. Thus, it is imperative to use techniques that are both power and bandwidth efficient for proper utilization of the communication resources.

Power Allocation has been an effective approach to mitigating the effect of fading channels in the quality of signal transmission over wireless channels. The system typically involves a mechanism of measuring the quality of the channel seen by the receiver and providing such information to the transmitter to adjust the amount of transmitted power. For instance, if the channel is good then less power is used while if the channel is bad then more power is used. Few modifications to this strategy have been proposed such as to send higher data rates rather than reducing the power if the channel is good or not to send at all if the channel is bad. These systems are considered as opportunistic systems since they take advantage of the information about the channel to optimize the communications process. The main issues for these systems are the need for a feedback link fast enough to track the time variation of the channel and not utilizing the message structure of the image or video signal to be transmitted in power allocation[1-2].

The rest of the paper is organized as follows..Section II presents the Problem Formulation. RMSE Optimization Using Power Allocation Methods are presented in section III. Section IV presents a brief view of Wavelets. Finally, Numerical Results and conclusions are drawn in section V.

II. PROBLEM FORMULATION

Efficient use of the multimedia limited battery power is one of the major challenges in information devices. The management of power becomes even more critical with devices integrating complex video signal processing techniques with communications. Some of the key technologies that affect the power in this respect are source signal compression, channel error control coding, and radio transmission. Power consumption of base band processing should also be taken into account. On the other hand, the work on improving the power has focused on separate components such as algorithms and hardware design for specific video and channel coders and low power transmitter design [3], [4]. Joint optimization of source compression, channel coding, and transmission to balance the quality of service and power requirements of the multimedia has only recently attracted interest[5]. The work by Appadwedula et al. [6], considers minimization of the total energy of a wireless image transmission system. By choosing the coded source bit rate for the image coder, redundancy for the Reed–Solomon (RS) coder, transmission power for the power amplifier and the number of fingers in the RAKE receiver, the total energy due to channel codec, transmission, and the RAKE receiver is optimized subject to end-to-end performance of the system. The proposed system is simulated for an indoor office environment subject to path loss and multipath. Significant energy saving is reported. In [7] and [8], by changing the accuracy of motion estimation different power and distortion levels for H.263 encoder are provided [9].The coded bits are packetized and unconventionally protected using RS codes and are transmitted over a code-division multiple-access system operating over a flat fading channel.

Depending on the execution location, power control algorithms can be categorized as either centralized or distributed. An optimum centralized power control algorithm which can achieve the minimum outage probability was studied in [3]. It is assumed that all the active link gains are available and remain constant during execution of the algorithm. This assumption, of course, is not realistic because of the high computational complexity required for the algorithm [10-12].

In the previous algorithms of power allocation methods only local information is used to adjust transmitting power. However, a normalization procedure is required in each iteration to determine transmitting power and, thus, these algorithms are not fully distributed. In this paper, a controlled power adaptation algorithm which does not need the normalization procedure is proposed. The excellent performance and the fully distributed property make our proposed algorithm a good choice for multimedia systems [13-16].

III. RMSE OPTIMIZATION USING POWER ALLOCATION METHODS

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits are $P = [P_1, P_2, \dots\dots\dots\dots\dots.. P_M]$ and the respective RMSEs at the bits be $RMSE = [RMSE_1, RMSE_2, \dots\dots\dots.. RMSE_M]$. Let $RMSE_T$ be the target RMSE. For a system with M bits per sample, there are 2M different samples to be transmitted.

The probability that ith sample with a decimal value of (i) is reconstructed is given by

$$P_i = \prod_{k=0}^{M-1} [p_k \vartheta(k) + (1 - p_k)\widetilde{\vartheta(k)}] \qquad (1)$$

Where p_k is the probability that the kth bit is in error.$\vartheta(k)$ is Conventional to zero if the indices of i and k are same and the value will be Conventional to 1 if the indices are different. The notation $\widetilde{\vartheta(k)}$] represents the binary inversion of $\vartheta(k)$.

The MSE for the above case is calculated as

$$MSE = \frac{1}{\sqrt{2^M - 1}} \sum_{k=0}^{M-1} P_i \qquad (2)$$

The MSE for other samples can be obtained following a similar procedure and the average MSE can be calculated by averaging over all possible samples. It is possible to show that, on average, all MSE values are approximately the same and hence equation (7) will be average MSE. The Root Mean

Square Error (RMSE) is obtained by taking the square root of (7)[17-18] .Note that the probability of the kth bit to be in error for the AWGN case is given by

$$PE_k = Q(\sqrt{2\frac{E_b}{N_o}(k)}) \tag{3}$$

In these systems, the MSE level is satisfied at each bit. Once the bit allocation is carried out, the power control takes a role of controlling the error caused by bits. On one hand, this algorithm must be reduced to minimize the interference at other bits, and, on the other hand, it must be sufficient for data communication [19,23-24].

3.1 Algorithm:

1. Initialize number of iterations
2. Initialize number of bits
3. Initialize power step size to ΔP.
4. Initialize$PAPR_{max.}$.
   - for i = 1 to iterations
5. Initialize power vector to all ones
6. Define two bits, R is recipient power and C is contributing power ,
   - for j = 1 to bits
7. Compute RMSE.
8. Update power of all the bits using
$$P_i^{n+1} = RMSE_i^n x P_i^n \tag{4}$$
9. Where
$$RMSE_i^n = \frac{MAX\ (RMSE_i^n, RMSE_T)}{RMSE_i^n} \tag{5}$$
   P_i^{n+1} =Power allocated in the n+1 state
   P_i^n = Power allocated in the n state
   $RMSE_i^n$=Root mean square error of k_{th} bit in n_{th} iteration
   $RMSE_T$ =Target Root Mean Square Error

10. Calculate the maximum power of each bit.
11. Repeat the same procedure 4 and 5 above but with the Contributor bit C incremented by one until all least significant bits are used.
12. Calculate the maximum MSE.
13. Plot Energy per Bit versus Bit error Rate.

IV. BER OF BPSK MODULATION

Modulation is the process by which signal waveforms are transformed and enabled to better withstand the channel impairments. The Q-function can be described as a function of error function defined over $[0, \infty)$ and is given by

$$erf(x) = \frac{2}{\sqrt{\pi}}\int_0^x e^{-y^2} dy \tag{6}$$

With erf(0)= 0 and erf (∞)=1

$$P_b = Q(\sqrt{2\gamma_b}) \tag{7}$$

$$P_s = 1 - [1 - Q(\sqrt{(2\gamma\_b\ )})]^2 \tag{8}$$

$$\gamma_s = 2\gamma_b = \frac{A^2}{N_o} \tag{9}$$

$$P_s \leq 2Q(\sqrt{\gamma_s}) + Q\left(\sqrt{2\gamma_s}\right) \leq 3Q(\sqrt{\gamma_s})$$

Where the Q function is defined as:

$$Q(x) \leq \frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{-\frac{x^2}{2}} dx \tag{10}$$

The Bit Error rate of BPSK involves two BPSK modulations on in-phase and quadrature components of the signal. The bit error probability is given by

$$Q(z) \leq \frac{1}{z\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx \tag{11}$$

$$P_{s} \le \frac{3}{\sqrt{2\pi\gamma_s}} e^{-0.5\gamma_s} \tag{12}$$

P_b Can be approximated from P_s by P_b as

$$P_b = \frac{P_s}{2} \tag{13}$$

The Bit Error Rate for BPSK signalling can be calculated by an approximation of symbol error rate using nearest neighbour approximation. The Symbol error probability can be approximated by

$$P_s = 2Q\left[\frac{2A\sin\frac{\pi}{M}}{\sqrt{2N_o}}\right] = 2Q\left[\sqrt{2\gamma_s}\,\mathrm{Sin}\,\frac{\pi}{M}\right] \tag{14}$$

V. WAVELETS

Wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. The wavelet transform has the ability to decorrelate an image both in space and frequency there by distributing energy compactly into a few low frequency and a high frequency coefficients. The efficiency of a wavelet based image compression scheme depends both on the wavelet filters chosen as well as on the coefficient quantization scheme. In the discrete wavelet transform, an image signal can be analysed by passing it through an analysis filter bank followed by decimation operation. The analysis filter bank consists of a low pass and high pass filter at each decomposition stage. when the signal passes through these filters it splits into two bands [17-18].
The low pass filter corresponds to an averaging operation, extracts the coarse information of the signal, The high pass filter corresponds to a differencing operation that extracts the detail information of the signal. The output of the filtering operation is then decimated by two.A two dimensional transform is accomplished by performing two separate one dimensional transforms. First the image is filtered along the row and decimated by two. It is then followed by filtering the sub image along the column and decimated by two. This operation splits the image into four bands, namely LL, LH, HL and HH respectively. The LL band is transmitted along the channel by allocating power allocation and one level of decomposition was taken into consideration. The four bands are transmitted over wireless channel and the coefficients are reconstructed using inverse transform.
The approximation coefficients are reconstructed using inverse discrete transform process and various parameters are studied in the proposed and conventional methods for three levels of sub band decomposition. This kind of two-dimensional DWT leads to a decomposition of approximation coefficients at level j in four components: the approximation at level j + 1, and the details in three orientations (horizontal, vertical, and diagonal).

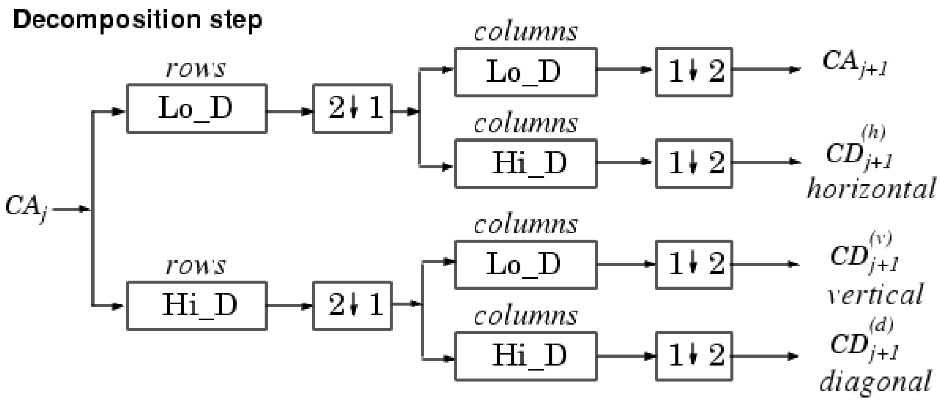

Fig.1 Image showing Decomposition Steps

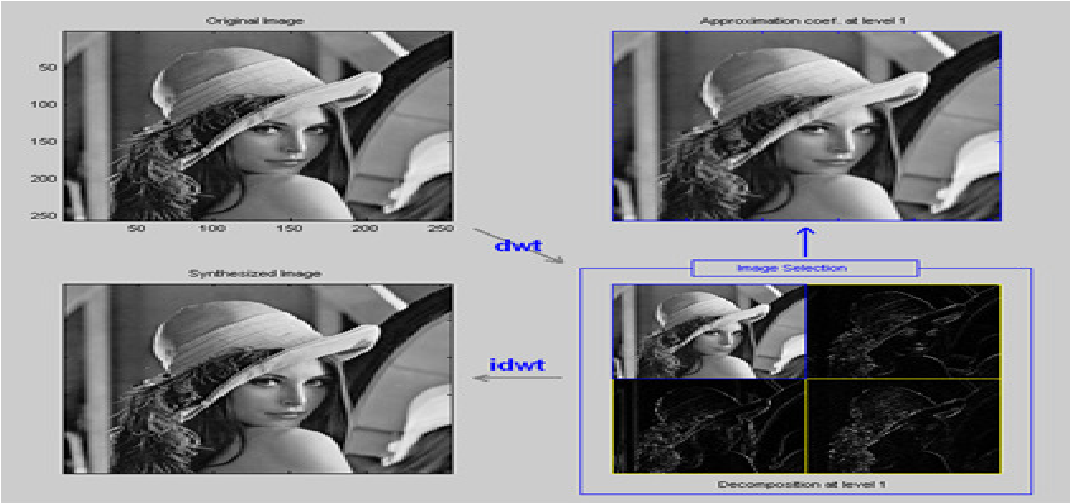

Fig.2 Image showing Approximated Coefficients at Level 1Decomposition

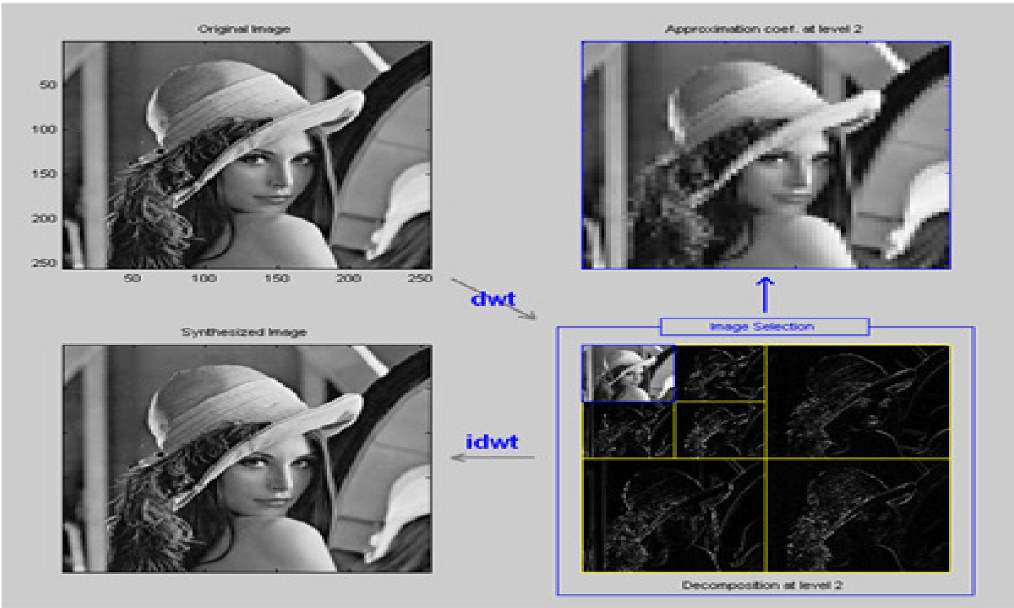

Fig.3 Image showing Approximated Coefficients at Level 2 Decomposition

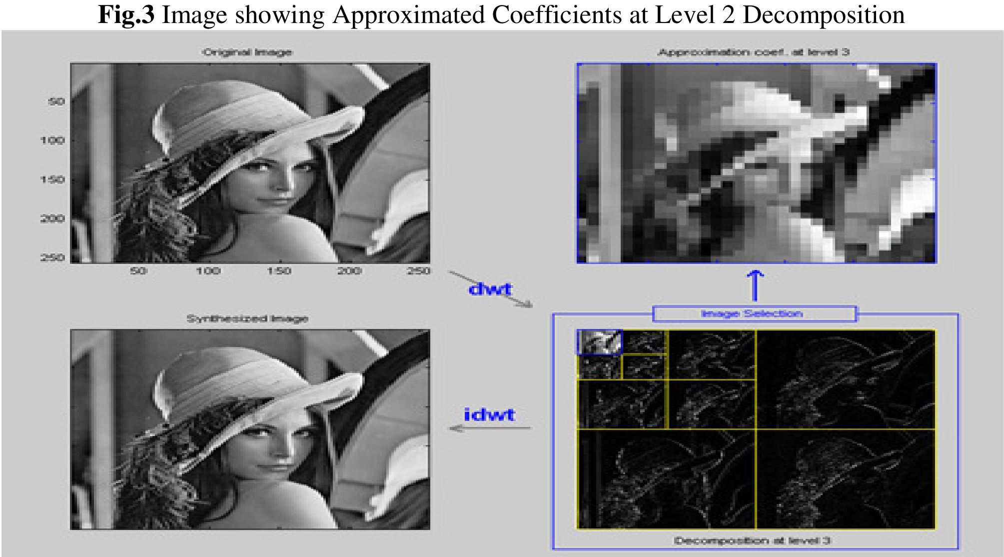

Fig.4 Image showing Approximated Coefficients at Level 3 Decomposition

VI. NUMERICAL RESULTS AND CONCLUSIONS

Bit Error Rate (BER) values are obtained for Conventional Power Adaptation Algorithm, Minimum Power Adaptation Algorithm and Maximum Controlled Power Adaptation Algorithms. The results obtained via equations (5), (6) and (10) are presented for AWGN channel in Fig. 4, 5 and 6. The improvement in performance obtained by the Minimum Power Adaptation Algorithm (MPAA) with low power as compared to the Maximum Power Adaptation Algorithm (MaPAA) with maximum power and the value of E_b/N_o at which the system is operating as shown in Fig. 2.A better Performance is observed in Maximum Power Adaptation Algorithm (MaPAA) compared with Conventional Power Adaptation Algorithm (CPAA) as shown in Fig.3

Fig.4 shows the plots of BER performance of BPSK modulation using haar wavelet at level 1, level 2 and level 3 using Conventional Power Adaptation Algorithm (CPAA), Minimum Power Adaptation Algorithm (MPAA) and Maximum Power Adaptation Algorithm (MaPAA) the plot proves that better Performance is observed in Maximum Power Adaptation Algorithm compared with Conventional Power Adaptation Algorithm as the power controlled is maximum. If the minimum power is considered, then Minimum Power Adaptation Algorithm exhibits better performance than the other two algorithms.

The plots shows that better Performance is observed in Maximum Power Adaptation Algorithm (MaPAA) compared with Conventional Power Adaptation Algorithm (CPAA) as the power is maximum. If the minimum power is considered, then Minimum Power Adaptation Algorithm exhibits better performance than the other two algorithms, since it uses minimum power. The plot shows that better Performance is observed in Maximum Power Adaptation Algorithm compared with Conventional Power Adaptation Algorithm as the power is maximum. If the minimum power is considered, then Minimum Power Adaptation Algorithm exhibits better performance than the other two algorithms. Both minimum power Adaptation Algorithm and Maximum Power Adaptation Algorithms show better BER performance in image transmission using three levels of haar wavelet compared with Conventional Power Adaptation Algorithm.

Table.1 shows the BER values of Image Transmission in AWGN using BPSK Modulation at different levels using Haar Wavelet. The performance in level 3 using Haar wavelet shows better quality of the image compared with the other levels of image transmission over wireless channels using Haar wavelet. Lower values of BER are observed in level 3 rather than level 1 and level 2 using Maximum Power Adaptation Algorithm.

Table 1: BER values of Image Transmission in AWGN using BPSK Modulation at different levels using Haar Wavelet

Modulation Type	**BPSK MODULATION**								
LEVEL	**Level 1**			**level 2**			**Level 3**		
Power Allocation Method	**Minimum Controlled Power Adaptation Algorithm**	**Maximum Controlled Power Adaptation Algorithm**	**Conventional Controlled Power Adaptation Algorithm**	**Minimum Controlled Power Adaptation Algorithm**	**Maximum Controlled Power Adaptation Algorithm**	**Conventional Controlled Power Adaptation Algorithm**	**Minimum Controlled Power Adaptation Algorithm**	**Maximum Controlled Power Adaptation Algorithm**	**Conventional Controlled Power Adaptation Algorithm**
E_b/N_o	**BER**	**BER**	**BER**	**BER**	**BER**	**BER**	**BER**	**BER**	**BER**
0	0.072	0.3526	0.5006	0.0727	0.3533	0.4993	0.0715	0.3217	0.4989
1	0.0432	0.3091	0.5003	0.0444	0.3102	0.5	0.0452	0.2873	0.4987
2	0.022	0.2649	0.4972	0.0232	0.2671	0.5006	0.0224	0.2495	0.4995
3	0.0092	0.2217	0.5	0.0097	0.2226	0.4994	0.0089	0.2119	0.4978
4	0.0024	0.1775	0.4965	0.0023	0.1753	0.4989	0.0023	0.1734	0.4993
5	0.0003	0.1321	0.4983	0.0003	0.1325	0.4978	0.0003	0.1393	0.499
6	0	0.0901	0.4986	0	0.0909	0.4991	0	0.1053	0.4993
7	0	0.0506	0.501	0	0.0515	0.502	0	0.074	0.5018
8	0	0.0159	0.5	0	0.016	0.4986	0	0.0491	0.5001
9	0	0.0008	0.4995	0	0.001	0.4992	0	0.028	0.4995

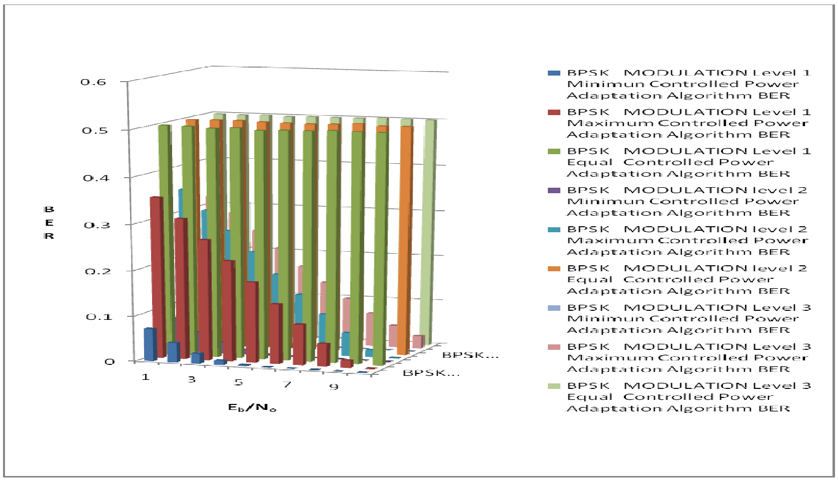

Fig.5 BER Performance for Image Transmission in AWGN for BPSK Modulations using Conventional, Minimum and Maximum Power Adaptation Algorithms

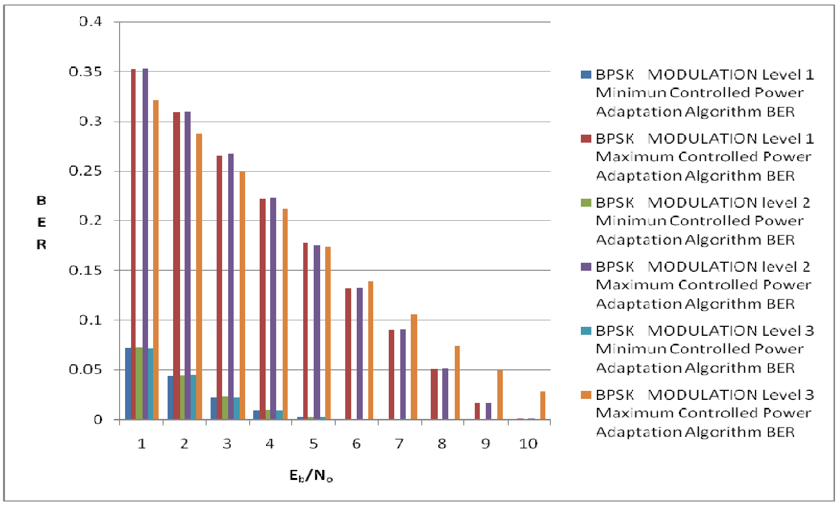

Fig.6 BER Performance for Image Transmission in AWGN for BPSK Modulations using Minimum and Maximum Power Adaptation Algorithms

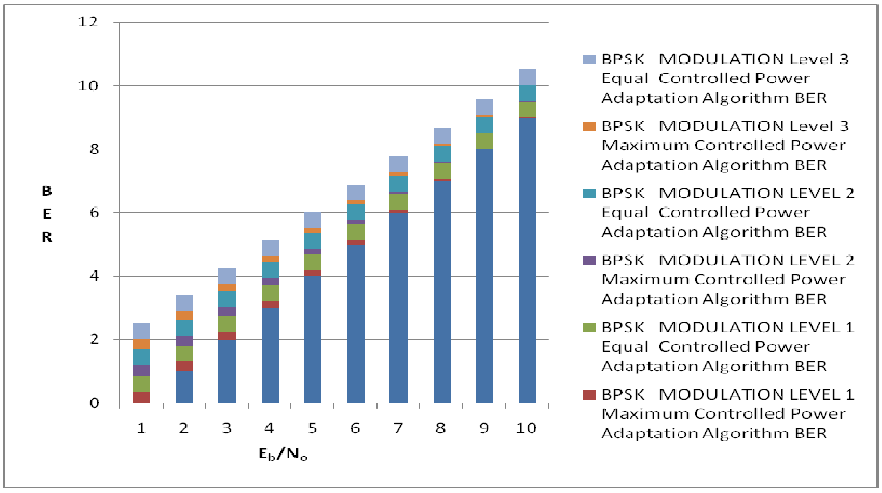

Fig.7 BER Performance for Image Transmission in AWGN for BPSK Modulations using Conventional and Maximum Power Adaptation Algorithms

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