*International Journal of Engineering Research and Development*
*eISSN : 2278-067X, pISSN : 2278-800X, www.ijerd.com*
*Volume 4, Issue 8 (November 2012), PP. 57-63*

# Wireless Image Transmission Using Maximum Power Adaptation Algorithm

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***Abstract:—***In this Paper, Optimization of error is considered using power adaptation algorithm while transmission is carried out The Maximum Power Adaptation algorithm(MAPAA) is based on updating the amount of power transmitted for each bit according to its importance in the image quality as measured by the mean-square error. This Maximum Power Adaptation Algorithm is used to find the optimum power distribution vector such that the RootMeanSquareError (RMSE) is minimized subject to the constraints that the power per bit is kept constant considering Maximum Root Mean Square Error. The above optimization is done for RMSE regardless of the average probability of bit error and the PAPR is kept below a certain limit. Maximum Power Adaptation Algorithm shows better performance compared to the case of Conventional power adaptation while reducing the Peak-to-Average Power (PAPR) Ratio.
***Keywords:—***Maximum, Mean Square Error, PAPR, RMSE

## I.INTRODUCTION

One of the most important and challenging goal of current and future communication is transmission of high quality images from source to destination quickly with least error, where limitation of the bandwidth is a prime problem. 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 Root Mean Square Error (RMSE) due to the limitations imposed by the wireless communication channels such as fading and multipath propagation. Furthermore, the user mobility makes such a task more difficult because of the time varying nature of the channel. 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 [2].With the increasing complexity of these communication systems comes increasing complexity in the type of content being transmitted and received. The early content of plain speech/audio and basic black and white images used in early radio and television has developed into high definition audio and video streams; and with the introduction of computers into the mix even more complex content needs to be considered from images, video and audio to medical and financial data. Techniques are continuously being developed to maximise data throughput and efficiency in these wireless communication systems while endeavouring to keep data loss and error to a minimum. Power adaptation 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.

The primary purpose of power control is to maintain the acceptable $E_b/N_o$ by meeting some PAPR requirements. So, it is obvious that all the transmitters should transmit with different power levels . The determination of different transmitting power levels becomes an important issue . This paper shows that the Maximum Power Adaptation Algorithm is well suited for multimedia like image and video signals, where different bits carry different amount of information. The scheme is specifically optimized for minimizing the mean square error (MSE) of the image or video signal rather than the bit error rate (BER) since it is more indicative of the image quality.

The rest of the paper is organized as follows. The noise used in this paper is AWGN .Section II presents the signal model. The Maximum Power Adaptation Algorithm is presented in section III. Section IV presents the simulation results. Finally, conclusions are drawn in section V.

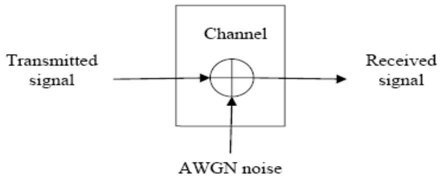
## II.PROBLEM FORMULATION

Efficient use of the multimedia power is one of the major challenges in information devices. The controlling 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 unequally protected using RS codes and are transmitted over a code-division multiple-access system operating over a flat fading channel.

The system is a typical binary phase shift keying (BPSK) digital communication system for multimedia transmission. The signal is sampled, quantized and then coded into binary bits for transmission. The transmitted BPSK signal is represented as

$$S(t) = \sum_{k=0}^{\infty} \sum_{i=0}^{M-1} \sqrt{w_{ib_{ki}}}\, g(t-(kM+i)T_b \quad (1)$$

The channel used in this paper is the additive white Gaussian noise (AWGN) channel and is as shown in the figure below:




Modulation is the process by which signal waveforms are transformed and enabled to better withstand the channel impairments. In a BPSK system the received signal is given by

$$Y = x + n \quad (2)$$

Where $x \in \{-A, A\}$ and $\sigma^2 = N_o$

The bit error probability is

$$P_{b} = \int_A^{\infty} \frac{1}{\sqrt{2\pi\frac{\sigma^2}{2}}} e^{-\frac{x^2}{\frac{\sigma^2}{2}}} \quad (3)$$

And the Q-function is given by

$$Q(x) = \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{x^2}{2}}\, dx \quad (4)$$

$$Q(x) = \left[\frac{1}{(1-a)x + a(x^2+b)^{0.5}}\right] \frac{1}{(2\pi)^{0.5}} e^{-\frac{x^2}{2}} \quad (5)$$

Equation (6) is widely used in Bit error rate calculation.
The Q-function can be described as a function of error function defined over $[0, \infty)$ and is given by

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

With $erf(0) = 0$ and $erf(\infty) = 1$

$$P_b = Q\left(\sqrt{2\gamma_b}\right) \quad (7)$$

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

Where the Q function is defined as:

$$Q(x) \leq \frac{1}{\sqrt{2\pi}} \int_x^{\infty} e^{-\frac{x^2}{2}}\, dx \quad (9)$$

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

$$Q(z) \leq \frac{1}{z\sqrt{2\pi}} e^{-\frac{x^2}{2}} dx \quad (10)$$

$$P_{s} \leq \frac{3}{\sqrt{2\pi\gamma_s}} e^{-0.5\gamma_s} \quad (11)$$

$P_b$ Can be approximated from $P_s$ by $P_b$ as

$$P_b = \frac{P_s}{2} \quad (12)$$

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

$$P_s = 2Q\left[\frac{2A\sin\frac{\pi}{M}}{\sqrt{2N_o}}\right] = 2Q\left[\sqrt{2\gamma_s}\,\text{Sin}\frac{\pi}{M}\right] \quad (13)$$

## III. MAXIMUM POWER ADAPTATION ALGORITHM (MAPAA)

When there are N number of images and M number of bits in a multimedia system, then the powers transmitted by the bits be $P = [P_1, P_2, \ldots\ldots\ldots\ldots\ldots P_M]$ and the respective RMSEs at the bits be $RMSE = [RMSE_1, RMSE_2, \ldots\ldots\ldots RMSE_M]$. Let $RMSE_T$ be the target RMSE. For a system with M bits per sample, there are $2^M$ different samples to be transmitted.
The probability that ith sample with a decimal value of (i) is reconstructed is given by

$$PD_i = \prod_{k=0}^{M-1}[p_k\vartheta(k) + (1-p_k)\widetilde{\vartheta(k)}] \quad (14)$$

Where $p_k$ is the probability that the $k_{th}$ bit is in error.$\vartheta(k)$ is equal to zero if the indices of i and k are same and the value will be equal 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

$$MSE = \frac{1}{\sqrt{2^M-1}}\sum_{k=0}^{M-1} PD_i \quad (15)$$

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)[15-18] .Note that the probability of the kth bit to be in error for the AWGN case is given by

$$P_k = Q\left(\sqrt{2\frac{E_b}{N_o}(k)}\right) \quad (16)$$

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 [23-24].

**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

$$P_i^{n+1} = RMSE_i^n x P_i^n \quad (17)$$

Where

$$RMSE_i^n = \frac{MAX(RMSE_i^n, RMSE_T)}{RMSE_i^n} \quad (18)$$

$P_i^{n+1}$ =Power allocated in the n+1 state
$P_i^n$ = Power allocated in the n state
$RMSE_i^n$=Root mean square error of $i^{th}$ bit in $n^{th}$ iteration
$RMSE_T$ =Target Root Mean Square Error

9. Calculate the maximum power of each bit.
10. Repeat the same procedure 8 and 9 above but with the Contributor bit C incremented by one until all least Significant bits are used.
11. Calculate the maximum MSE.
12. Plot Energy per Bit versus RMSE, PSNR, BER.

## IV. NUMERICAL RESULTS AND CONCLUSIONS

Fig.1 shows the Original image. Image transmission over AWGN is considered with M = 8 bpp for Conventional and Maximum power adaptation methods. The improvement in performance obtained by the Conventional power adaptation method is affected by the Maximum Power Adaptation Algorithm and the values are shown in Tabular forms as Table I and Table II. Better Performance of image quality is analysed using Peak Signal to Noise Ratio (PSNR) which is observed in Maximum Power Adaptation Algorithm (MAPAA) compared with Conventional Power Adaptation Algorithm (CPAA) as shown in Fig.3. Fig.2 shows the received image using Maximum Power Adaptation Algorithm. The image proves that better Performance is observed in Maximum Power Adaptation Algorithm compared with Conventional Power Adaptation Algorithm as the power adapted is maximum.

Fig.3, Fig.4 and Fig.5 shows the plots of RMSE, PSNR and BER performance of Maximum Power Adaptation Algorithm. Ihe plot proves that better Performance is observed in Maximum Power Adaptation Algorithm compared with conventional Power Adaptation Algorithm as the power is maximum.

Fig.5 shows the plots of BER performance of BPSK modulation using Maximum Power Adaptation Algorithm. Both Conventional power Adaptation Algorithm and Maximum Power Adaptation Algorithms shows better BER performance in image transmission using MAPAA rather than CPAA with higher gain.

***Fig. 1*** *Original Image*

***Fig.2*** *Images obtained in transmission over AWGN using Maximum Power Adaptation Algorithm*

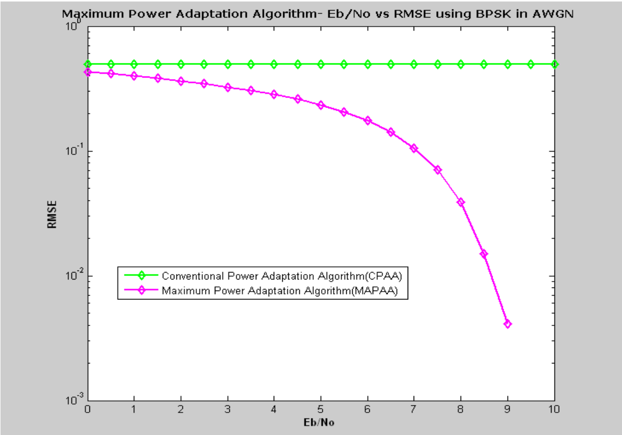



***Fig.3*** *Plot showing PSNR over AWGN using Maximum Power Adaptation Algorithm and Conventional power Adaptation Algorithm*

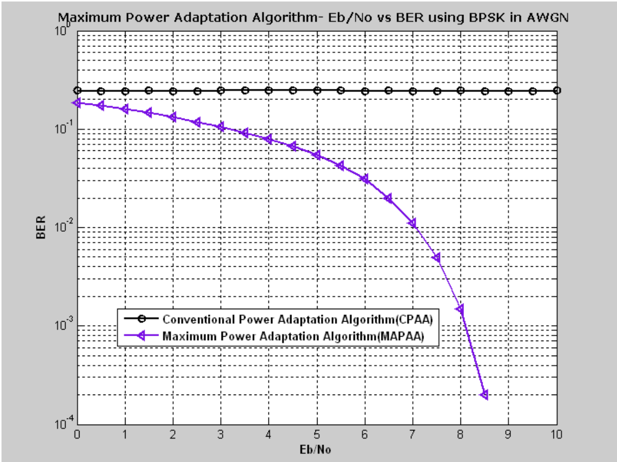



***Fig.4*** *Plot showing RMSE over AWGN using Maximum Power Adaptation Algorithm and Conventional power Adaptation Algorithm*

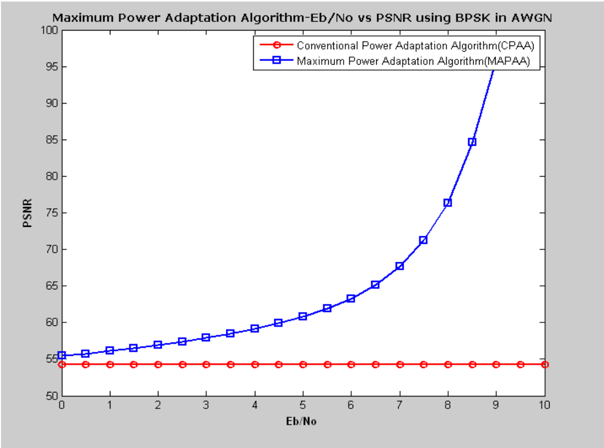



***Fig.5*** *Plot showing RMSE over AWGN using Maximum Power Adaptation Algorithm and Conventional power Adaptation Algorithm*

**Table I:** RMSE, PSNR, BER values of Image Transmission using Maximum Power Adaptation Algorithm and Conventional power Adaptation Algorithm

| Maximum Power Adaptation Algorithm(MAPAA) | | | |
|---|---|---|---|
| **$E_b/N_0$(dB)** | **RMSE** | **PSNR** | **BER** |
| 0 | 0.432 | 55.4552 | 0.1874 |
| 0.5 | 0.4162 | 55.7781 | 0.1732 |
| 1 | 0.3994 | 56.1368 | 0.1594 |
| 1.5 | 0.382 | 56.5237 | 0.146 |
| 2 | 0.3644 | 56.9322 | 0.1329 |
| 2.5 | 0.3448 | 57.4138 | 0.119 |
| 3 | 0.325 | 57.9274 | 0.106 |
| 3.5 | 0.3042 | 58.5006 | 0.0928 |
| 4 | 0.2822 | 59.153 | 0.0801 |
| 4.5 | 0.2594 | 59.8846 | 0.0676 |
| 5 | 0.2344 | 60.7664 | 0.0545 |
| 5.5 | 0.2064 | 61.8724 | 0.0426 |
| 6 | 0.1753 | 63.2879 | 0.031 |
| 6.5 | 0.1421 | 65.1132 | 0.02 |
| 7 | 0.106 | 67.6557 | 0.011 |
| 7.5 | 0.0698 | 71.2815 | 0.0048 |
| 8 | 0.038 | 76.5581 | 0.0015 |
| 8.5 | 0.0149 | 84.6786 | 0.0003 |
| 9 | 0.0057 | 93.056 | 0 |
| 9.5 | 0 | Inf | 0 |
| 10 | 0 | Inf | 0 |

| Conventional Power Adaptation Algorithm(MAPAA) | | | |
|---|---|---|---|
| **$E_b/N_0$(dB)** | **RMSE** | **PSNR** | **BER** |
| 0 | 0.4953 | 54.2673 | 0.2453 |
| 0.5 | 0.4951 | 54.2796 | 0.2452 |
| 1 | 0.4947 | 54.2643 | 0.2447 |
| 1.5 | 0.4945 | 54.2688 | 0.2446 |
| 2 | 0.4942 | 54.2553 | 0.2442 |
| 2.5 | 0.4951 | 54.271 | 0.2451 |
| 3 | 0.4945 | 54.2839 | 0.2445 |
| 3.5 | 0.4957 | 54.2757 | 0.2457 |
| 4 | 0.4946 | 54.2941 | 0.2446 |
| 4.5 | 0.495 | 54.2673 | 0.245 |
| 5 | 0.4958 | 54.2779 | 0.2458 |
| 5.5 | 0.4948 | 54.2757 | 0.2448 |
| 6 | 0.4948 | 54.2758 | 0.2448 |
| 6.5 | 0.4944 | 54.2697 | 0.2444 |
| 7 | 0.495 | 54.2699 | 0.245 |
| 7.5 | 0.4953 | 54.2772 | 0.2453 |
| 8 | 0.4952 | 54.2641 | 0.2452 |
| 8.5 | 0.4946 | 54.2897 | 0.2447 |
| 9 | 0.4946 | 54.2758 | 0.2446 |
| 9.5 | 0.4942 | 54.2687 | 0.2442 |
| 10 | 0.4946 | 54.2858 | 0.2446 |

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