

Wireless Video Transmission with Maximum Power Adaptation Algorithm and Convolutioncode Rate-1/2 using Lab View

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Abstract - In this Paper, Power is controlled by reducing the error in the data while transmission is carried. This transmission takes place by bits. The proposed algorithm was based on updating the amount of power transmitted for each bit according to its importance in the Video quality as measured by the mean-square error. This Maximum Power Adaptation Algorithm along convolution coding is used to find the optimum power distribution vector such that the RMSE is minimized subject to the constraints that the power per bit is kept constant considering Maximum Root Mean Square Error using Lab view. 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, RRMSE.

I. INTRODUCTION

One of the most important and challenging goal of current and future communication is transmission of high quality Videos from source to destination quickly with least error where limitation of 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 (RRMSE) 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 Videos 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 Videos, 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 control 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 Eb/No 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 Video and video signals, where different bits carry different amount of information. The scheme is specifically optimized for minimizing the Root mean square error (RRMSE) of the Video rather than the bit error rate (BER) since it is more indicative of the Video 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

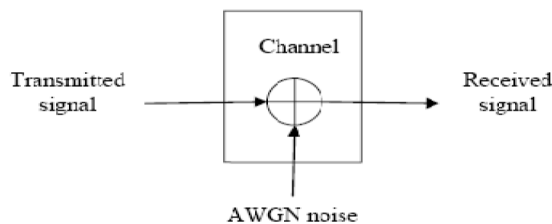
Efficient use of the multimedia power is one of the major challenges in information devices. The controlling of power becomes even more critical with devices integrating complex video signal processing techniques with communications. Some of the key technologies that affect the power in this respect 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 Video transmission system. By choosing the coded source bit rate for the Video coder, redundancy for the Reed-Solomon (RS) coder is considered, the total energy due to channel codec, transmission, is optimized subject to performance of the system. 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 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[10]. The transmitted BPSK signal is represented as

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

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[11-13].

In a BPSK system the received signal is given by $Y = x + n$ (2)

Where $x \in \{-A, A\}$ and $\sigma^2 = N_0$
 The bit error probability is

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

And the Q-function is given by

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

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

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

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

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

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

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

$$\gamma_s = 2\gamma_b = \frac{A^2}{N_0}$$

$$P_s = 2Q(\sqrt{\gamma_s}) + Q(\sqrt{2\gamma_s}) - 3Q(\sqrt{\gamma_s}) \quad (11)$$

Where the Q function is defined as:

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

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

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

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

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

$$P_s = 2Q\left[\frac{2A \sin \frac{\pi}{M}}{\sqrt{2N_0}}\right] = 2Q\left[\sqrt{2} \frac{A}{N_0} \sin \frac{\pi}{M}\right] \quad (13)$$

Gray code, in which the bits corresponding to neighboring symbols differ by exactly one bit since symbol errors are most likely going to occur by decoding into neighboring decision regions, this reduces the number of bit errors.

Gray coding can be thought of as two independent BPSK systems. Gray coding is particularly useful at low SNR (e.g., for heavily coded systems), where symbol errors happen more often. For example, in a coded system, we would pass up fewer bit errors to the decoder for the same number of symbol errors.

Consider a 2^n -ary constellation in which each point is represented by a binary string $b = (b_1, \dots, b_n)$. The bit assignment is said to be Gray coded if, for any two constellation points b and b^1 which are nearest neighbours, the bit representations b and b^1 differ in exactly one bit location[14-15].

III. MAXIMUM POWER ADAPTATION ALGORITHM (MAPAA)

When there are N number of Videos and M number of bits in a multimedia system, then the powers transmitted by the bits are $P = [P_1, P_2, \dots, P_M]$ and the respective RRMSEs at the bits

be $RRMSE = [RRMSE_1, RRMSE_2, \dots, \dots, RRMSE_M]$. Let $RMSE_T$ be the target RRMSE. For a system with M bits per sample, there are 2^M different samples to be transmitted [16-17].

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

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

Where p_k is the probability that the k th bit is in error. (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 $\overline{\vartheta(k)}$ represents the binary inversion of (k) .

The RMSE for the above case is calculated as

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

The RMSE for other samples can be obtained following a similar procedure and the average RMSE can be calculated by averaging over all possible samples. The Root mean square error (RRMSE) is obtained by taking the square root of (7) [15-18]. The probability of the k th bit to be in error is given by

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

In these systems, the RMSE 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 P .
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 RRMSE.
8. Update power of all the bits using

$$P_i^{n+1} = RRMSE_i^n \times P_i^n \quad (17)$$

Where

$$RRMSE_i^n = \frac{\text{MAX}(RRMSE_i^n, RRMSE_T)}{RRMSE_i^n} \quad (18)$$

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
 $RRMSE_T$ = 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 RMSE.

12. Plot Energy per Bit versus RRMSE, PSNR, BER.

IV. NUMERICAL RESULTS AND CONCLUSIONS

Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) is a platform and development environment for a visual programming language from National Instruments. The purpose of such programming is automating the usage of processing and measuring equipment in any laboratory setup. LabVIEW is commonly used for data acquisition, instrument control, and industrial automation. In this first the image is given to IMAQ read file where the image is read from a file and then the image is converted into array using IMAQ image to array block then the rows and columns of image pixels are calculated and all are initialized with zeros and now by using the math script node the image is converted into binary bits. Now the binary image is applied to PSK modulator then AWGN noise is added and decimates the over samples and then the bits are passed through convolution coding block. This process is repeated for “with coding” by first passing the binary data to convolution coding block followed by above process followed by decoding an. The graph was plotted between theoretical, no coding and with coding of binary data that was obtained from the original image.

Fig.1 shows the Original Video transmission over AWGN using Conventional and Maximum power adaptation methods with convolution codes of code rate-1/2. The performance obtained by the Conventional power adaptation method is affected by the Maximum Power Adaptation Algorithm and the values are shown in Tabular forms. Better Performance of MeanSquareError(MSE) is observed in Maximum Power Adaptation Algorithm (MAPAA) compared with Conventional Power Adaptation Algorithm (CPAA) as shown in Fig.1,2,3,4,5,6,7,8,9

Fig.2 shows the received Video using Maximum Power Adaptation Algorithm for frame 0. The Video proves that better Performance is observed in Maximum Controlled 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 MSE with and without coding performance of Maximum Power Adaptation Algorithm with code rate 1/2. The plot proves that better Performance is observed in Maximum Power Adaptation Algorithm compared with Conventional Power Adaptation Algorithm as the power adapted is maximum. In frame 0 and frame 1 transmission 7 to 8 dB gain is achieved and higher gains are achieved as the frames are increasing. This shows that a video transmission achieves higher gains with maximum power adaptation and convolution codes with code rate-1/2 using Lab view.

TableI: MSE values of frame 0, 1,2,3,4 with and without coding

FRAME 0			FRAME 1		FRAME 2		FRAME 3		FRAME 4	
E_b/N_0	MSE(NO CODING)	MSE(CODING)	MSE(NO CODING)	MSE(CODING)	MSE(NO CODING)	MSE(CODING)	MSE(NO CODING)	MSE(CODING)	MSE(NO CODING)	MSE(CODING)
0	NaN	NaN	2.31788	2.3695	2.54194	2.35971	2.59993	2.33251	2.65363	2.28541
1	2.2743	2.1266	2.39567	2.28716	2.57781	2.2004	2.59618	2.2152	2.62791	2.20072
2	2.2375	2.0525	2.36765	2.21856	2.54216	2.12938	2.56534	2.14854	2.59039	2.12249
3	2.2106	1.9940	2.33885	2.15851	2.50984	2.07323	2.53568	2.08683	2.56317	2.06691
4	2.1899	1.9501	2.31153	2.11072	2.48881	2.02459	2.51363	2.04274	2.53707	2.02123
5	2.1703	1.9068	2.291	2.06549	2.46892	1.98691	2.48854	2.00015	2.52049	1.98155
6	2.1521	1.8765	2.27357	2.03335	2.45372	1.95254	2.47295	1.96761	2.50536	1.94992
7	2.1405	1.8466	2.26254	2.00752	2.43669	1.9265	2.45953	1.9442	2.49132	1.92103
8	2.1248	1.8222	2.24882	1.98315	2.42476	1.90475	2.4466	1.9169	2.47469	1.89772
9	2.1145	1.8032	2.23923	1.96235	2.41598	1.8818	2.43777	1.89726	2.465533	1.87617

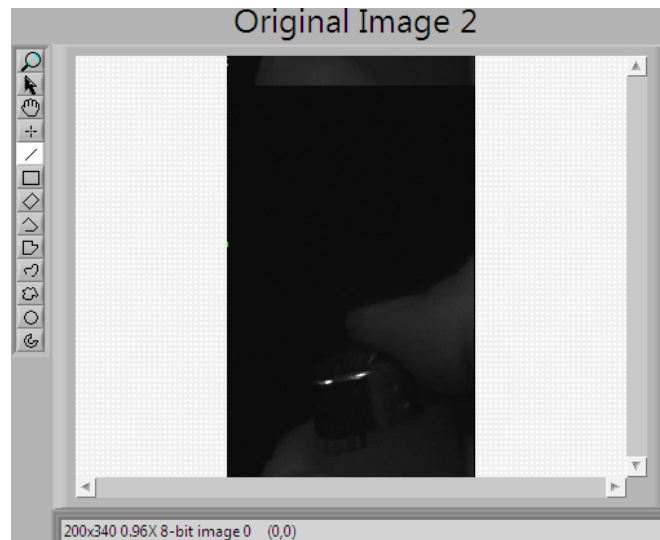


Fig.1. Frame 0 of Original Image

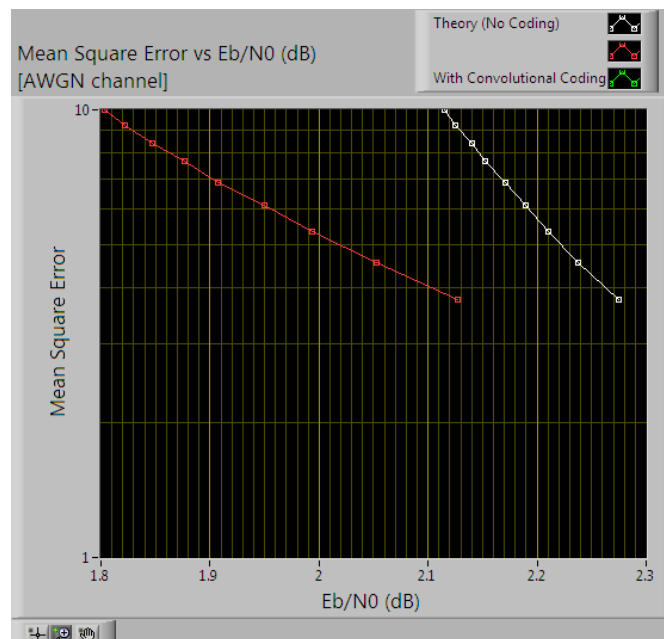


Fig.2. Plot Showing MSE values of Frame 0 for Coding and No Coding



Fig.3. Frame 1 of Original Image



Fig.4. Plot Showing MSE values of Frame 1 for Coding and No Coding

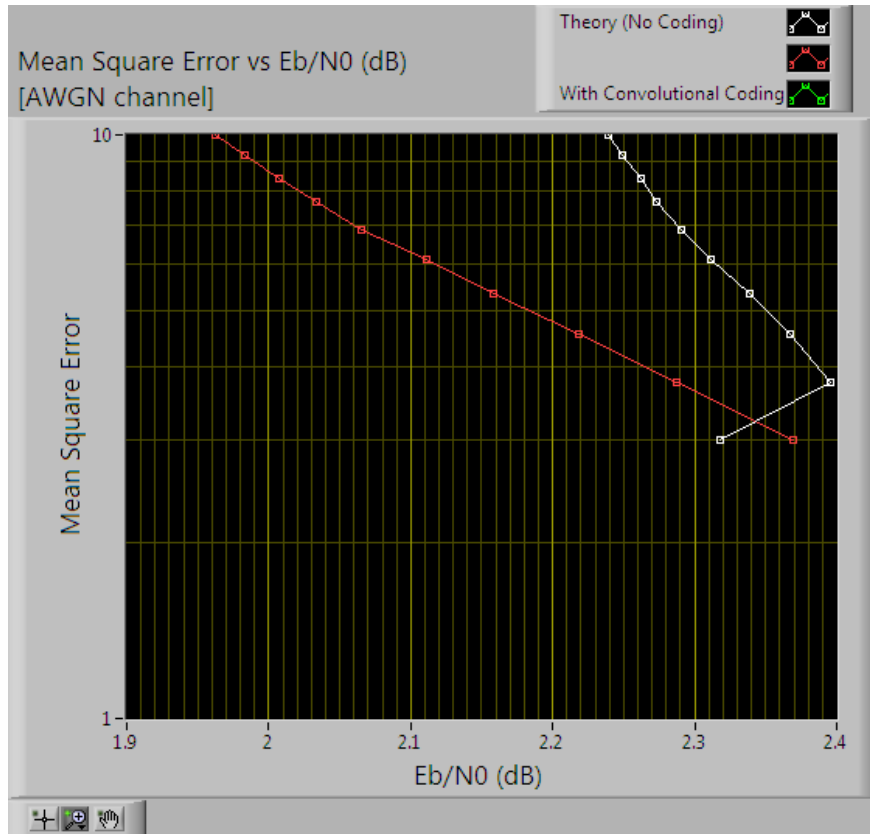


Fig.5 Plot Showing MSE values of Frame 2 for Coding and No Coding

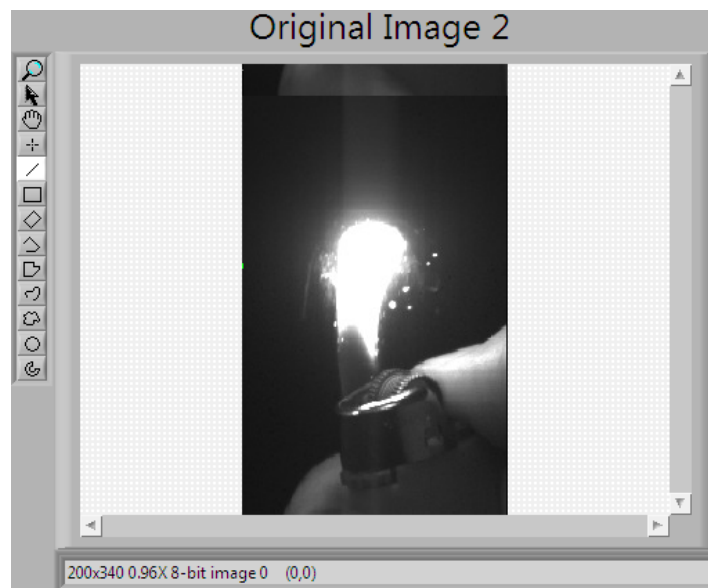


Fig.6. Frame 3 of Original Image

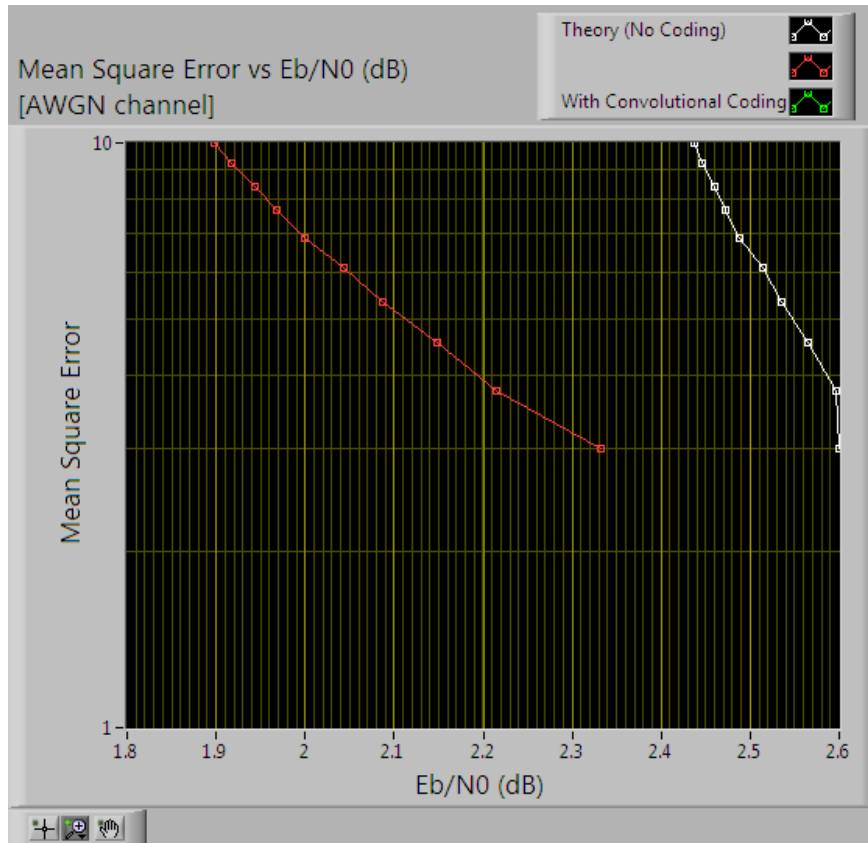


Fig.7. Plot Showing MSE values of Frame 3 for Coding and No Coding



Fig.8. Frame 4 of Original Image

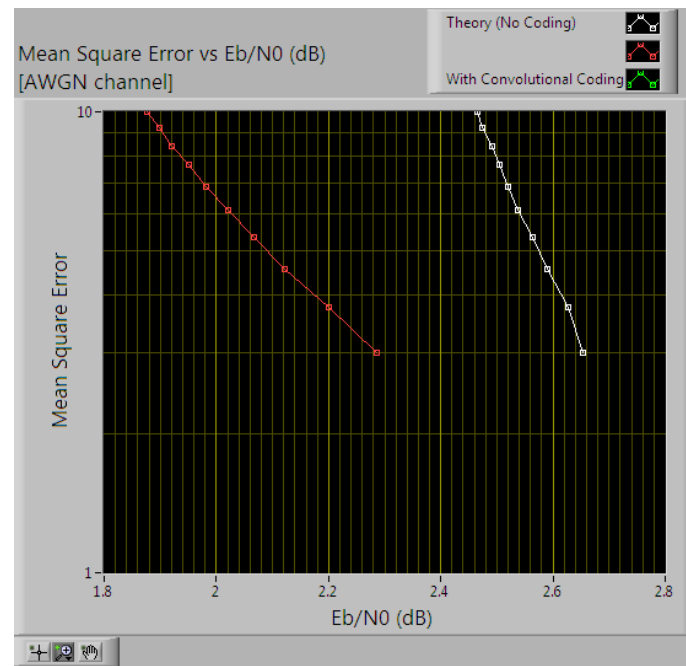


Fig.9. Plot Showing MSE values of Frame 4 for Coding and No Coding

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