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Peak to Average Power Ratio (PAPR) Reduction Technique in Orthogonal Frequency Division Multiplexing (OFDM) Using Block Coding

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Abstract: Orthogonal Frequency Division Multiplexing (OFDM) signal is considered a good candidate for wireless systems because it offers diversity gain in frequency selective channels. As in other multicarrier schemes, however, OFDM suffers from high peak to average power ratio (PAPR). This is a major drawback of the scheme and ways of minimizing the PAPR have been researched. Block coding scheme is the technique to reduce the peak-to-average power ratio of OFDM signals and also to detect transmission errors. The reason is that in the time domain, a multicarrier signal is the sum of many narrowband signals. At some time instances, this sum is large and at other times is small, which means that the peak value of the signal is substantially larger than the average value. This high PAR is one of the most important implementation challenges that face OFDM, because it reduces the efficiency. The main purpose in this work, is to make a comparison over the PAPR reduction technique using block coding and without block coding. The capability of Block Coding scheme to reduce the Bit Error Rate (BER) in an OFDM system was also measured. The simulation developed in Matlab simulation environment.

Keywords: OFDM; PAPR; Bit Error Rate:

1. Introduction

OFDM has a high tolerance to multipath signals and is spectrally efficient making it a good candidate for future wireless communication systems. One disadvantage of OFDM is the peak of the signal can be up to N times the average power (where N is the number of carriers) [1]. These large peaks increase the amount of intermodulation distortion resulting in an increase in the error rate. The average signal power must be kept low in order to prevent the transmitter amplifier limiting. Minimizing the PAPR allows a higher average power to be transmitted for a fixed peak power, improving the overall signal to noise ratio at the receiver. It is therefore important to minimize the PAPR [2].

There is a wide range of methods developed to solve the problem of high PAPR. Block coding scheme is the method to solve this problem. There are several technique in block coding to reduce PAPR such as Reed Solomon (RS) codes, Hamming Code, and Low density parity check (LDPC) codes [3]. In this work, Reed Solomon (RS) technique is applied. The work investigates technique to reduce PAPR in OFDM system and analysis of PAPR reduction technique base on block coding method, development of simulation for PAPR reduction technique in OFDM system using Matlab simulation environment and analysis of performance of block coding technique and uncoded base on the simulation [4].

2. Literature Review

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Block Coding is one of the leading methods used to reduce PAPR in OFDM system due to its simple algorithm, implementation and distortion less properties. A block coding scheme has been proposed by Jones, Wilkinson and Barton in 1994 to combat the high PAPR exhibits by OFDM system that severely limits its usage in Wireless Local Area Network environment [4]. This is because if the amplifiers are to be operated with a high input back-off (IBO) to avoid the severe nonlinear distortion cause by high PAPR, the power efficiency of the amplifier will be very low. However, power efficiency is of critical importance for indoor wireless systems with portable terminals. Moreover the cost of the amplifier will be very high and will be not economical in the corporate point of view as there are cheaper alternatives. Therefore block coding scheme is widely preferred as it reduces PAPR with simple complexity like Reed-Solomon. Reed-Solomon codes are non-binary cyclic error correcting codes with a wide range of applications in digital communications and storage. Reed-Solomon error correction scheme works by first constructing a polynomial from the data symbols to be transmitted and then sending an over-sampled plot of the polynomial instead of the original symbols themselves. Because of the redundant information contained in the over-sampled data, it is possible to reconstruct the original polynomial and thus the data symbols even in the face of transmission errors, up to a certain degree of error [5]. The properties of Reed-Solomon codes make them especially well suited to applications where errors occur in bursts. This is because it does not matter to the code how many bits in a symbol are in error, if multiple bits in a symbol are corrupted, it only counts as a single error. Conversely, if a data stream is not characterized by error bursts or dropouts but by random single bit errors, a Reed- Solomon code is usually a poor choice. RS block codes have four basic properties which make them powerful codes for digital communications. A RS decoder acts on multi-bit symbols rather than only on single bits. Thus, up to eight bit-errors in a symbol can be treated as a single symbol error. Strings of errors, or bursts, are therefore handled efficiently. The RS codes with very long block lengths tend to average out the random errors and make block codes suitable for use in random error correction. RS codes are well-matched for the messages in a block format, especially when the message block length and the code block length are matched. The complexity of the decoder can be decreased as the code block length increases and the redundancy overhead decreases.

2.1 Previous Work

Channel coding is a widely used technique for the reliable transmission and reception of data. Generally systematic linear cyclic codes are used for channel coding [6]. In 1948, Shannon introduced the linear block codes for complete correction of errors . Cyclic codes were first discussed in a series of technical notes and reports written between 1957 and 1959 by Prange. This led directly to the work published in March and September of 1960 by Bose and Ray-Chaudhuri the BCH codes. In 1959, Irving Reed and Gus Solomon described a new class of error-correcting codes called Reed-Solomon codes. Originally Reed-Solomon codes were constructed and decoded through the use of finite field arithmetic which used nonsingular Vandermonde matrices. In 1964 Singleton showed that this was the best possible error correction capability for any code of the same length and dimension [7]. Codes that achieve this "optimal" error correction capability are called Maximum Distance Separable (MDS). Reed-Solomon codes are by far the dominant members, both in number and utility, of the class of MDS codes. MDS codes have a number of interesting properties that lead to many practical consequences. The generator polynomial construction for Reed-Solomon codes is the approach most commonly used today in the error control literature [8]. This approach initially evolved independently from Reed-Solomon codes as a means for describing cyclic codes. Gorenstein and Zierler then generalized Bose and Ray-Chaudhuri's work to arbitrary Galois fields of size p m , thus developing a new means for describing Reed and Solomon's "polynomial codes" [8]. After the discovery of Reed-Solomon codes, a search began for an efficient decoding algorithm [9]. In 1960, Reed and Solomon proposed a decoding algorithm based on the solution of sets of simultaneous equations.Though much more efficient than a look-up table, Reed and Solomon's algorithm is still useful only for the smallest Reed-Solomon codes. In 1960 Peterson provided the first explicit description of a decoding algorithm for binary BCH codes, His "direct solution" algorithm is quite useful for correcting small numbers of errors but becomes computationally intractable as the number of errors increases. Peterson's algorithm was improved and extended to non - binary codes by Gorenstein and Zierler (1961), Chien (1964), and Forney (1965). These efforts were productive, but Reed-Solomon codes capable of correcting more than six or seven errors still could not be used in an efficient manner. In 1967, Berlekamp demonstrated his efficient decoding algorithm for both non - binary BCH and Reed-Solomon codes. Berlekamp's algorithm allows for the efficient decoding of dozens of errors at a time using very powerful Reed-Solomon codes [10]. In 1968 Massey showed that the BCH decoding problem is equivalent to the problem of synthesizing the shortest Linear Feedback Shift Register capable of generating a given sequence [11]. Massey then demonstrated a fast shift register-based decoding algorithm for BCH and Reed-Solomon codes that is equivalent to Berlekamp's algorithm. This shift register-based approach is now referred to as the Berlekamp-Massey algorithm. In 1975 Sugiyama, Kasahara, Hirasawa, and Namekawa showed that Euclid's algorithm can also be used to efficiently decode BCH and Reed- Solomon codes. Euclid's algorithm is a means for finding the greatest common divisor of a pair of integers [12]. It can also be extended to more complex collections of objects, including certain sets of polynomials with coefficients from finite fields [13]. As mentioned above, Reed – Solomon codes are based on the finite fields so they can be extended or shortened. In this thesis Reed-Solomon codes used for decoding in the compact discs are encoded and decoded. The generator polynomial approach has been used for encoding and decoding of data [11].

3. Methodology

Development of Simulation System i shwon in Fig.1. that is consit of various blocks.

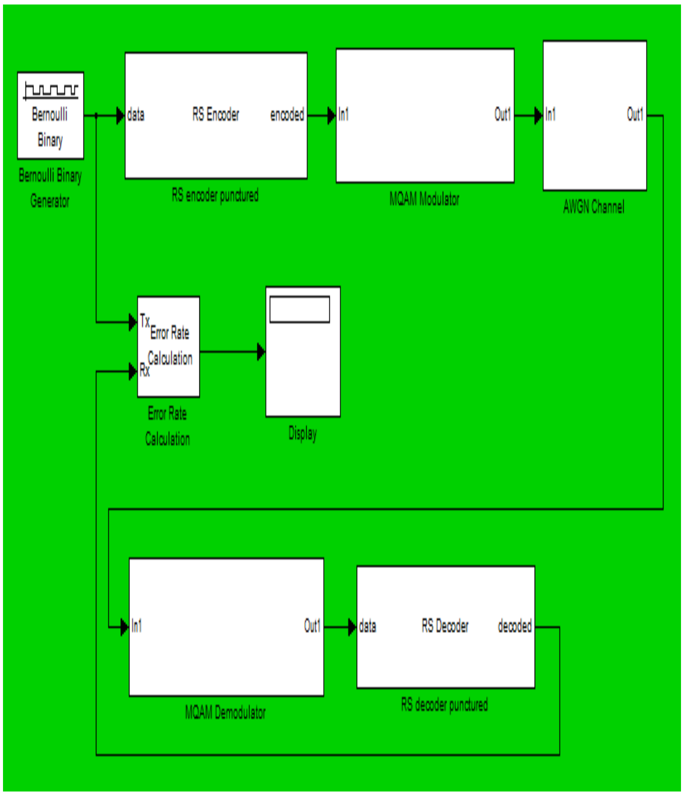

Fig. 1 -Submasked Simulation Block (Coded)

3.1 Coded Simulation Block

The signal is coded by Block Coding technique. Therefore reduction of the PAPR will be obtained. The Fig. 1 shows Reed Solomon Encoder Punctured, Fig. 2 shows MQAM Modulator, Fig. 3 shows AWGN Channel, Fig. 4 shows AWGN Channel, Fig. 5 shows MQAM Demodulator and Fig. 6 shows Solomon Decoder Punctured

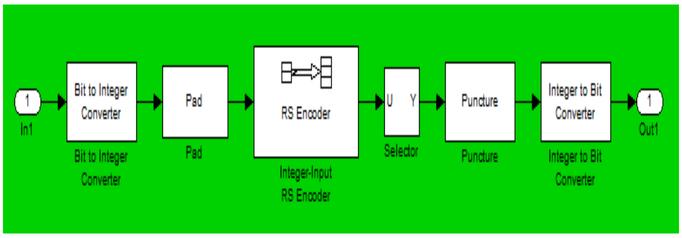

Fig. 2 -Reed Solomon Encoder Punctured

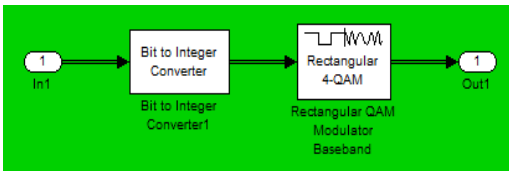

Fig. 3 -MQAM Modulator

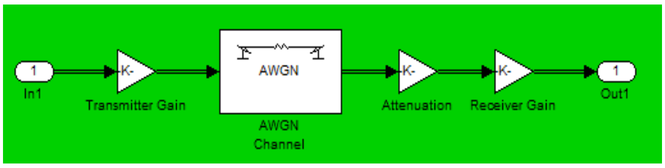

Fig. 4 -AWGN Channel

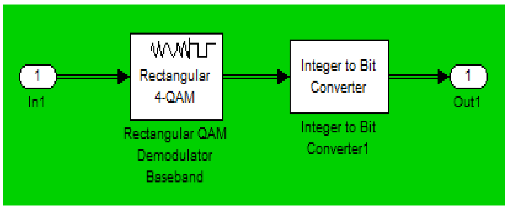

Fig. 5 -MQAM Demodulator

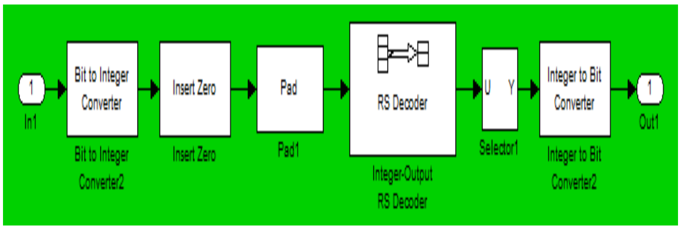

Fig. 6 -Reed Solomon Decoder Punctured

RS encoder will encode the data generated from the data source (Bernoulli Binary Generator) and modulated by the MQAM. The signal will go through the AWGN channel where the Signal to Noise Ratio (SNR) and input power can be changed to suit the analysis need. RS decoder receive demodulated data from MQAM. The output will be generated by the output sink. BER will be calculated by comparing the transmitted data with the received data.

3.2 Uncoded Simulation Block

The data was not coded with any of the Block Coding technique. Therefore no reduction of the PAPR will be obtained. This model was developed in order to give a comparison analysis of the performance with the block coded model as shown in Fig. 7.

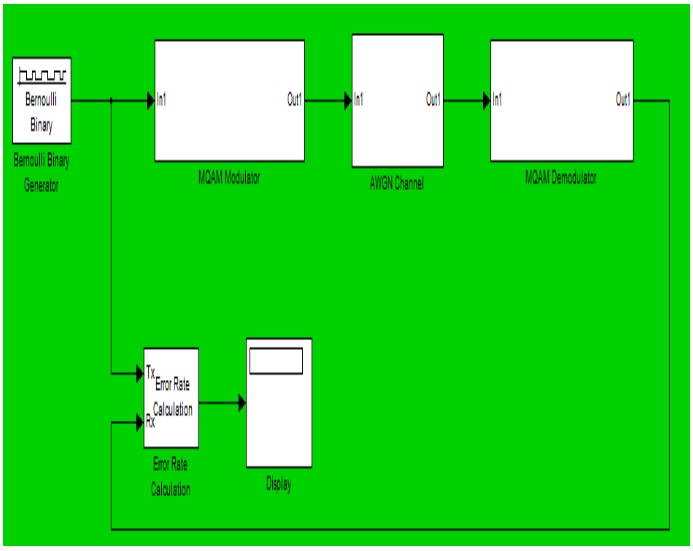

Fig. 7 - Submasked Simulation Block (Uncoded)

For the uncoded simulation system, the data was generated by Bernoulli Random Binary Generator and will be encoded by MQAM Modulator. The OFDM signals will go through the AWGN channel where the Signal to Noise Ratio (SNR) and input power can be changed to suit the analysis need. The output sink received the signal demodulated by MQAM. BER will be calculated by comparing the transmitted data with the received data.

4. Results and Discussion

Comparison Constellation Coded vs Uncoded is performed in order to analyses the performance. The constellation of simulation block can be viewed after put the Discrete-time Scatter Plot Scope (output sink) such as in Fig. 8 and Fig. 9

i) Coded Simulation Block

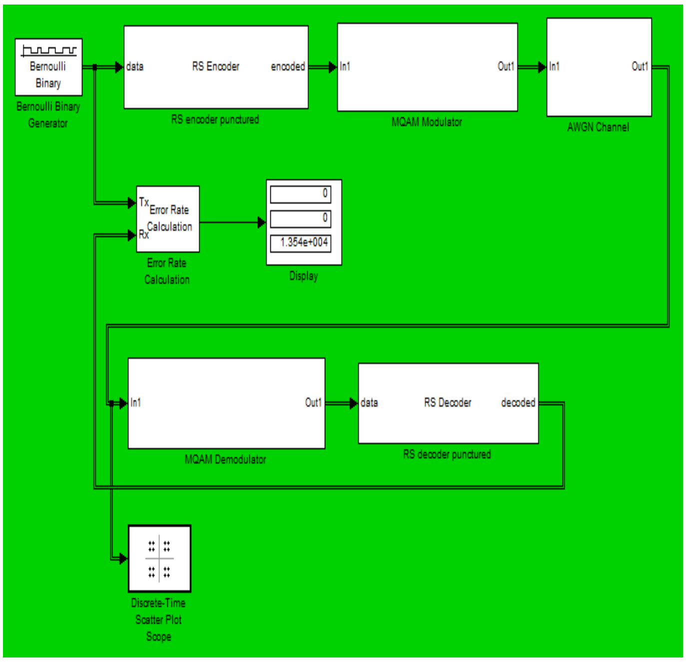

Fig. 8 - Simulation Block

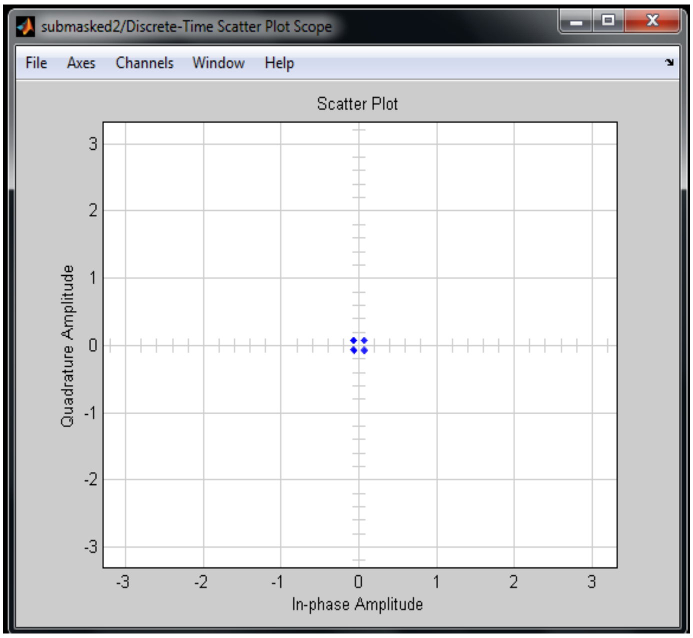

Fig. 9 - Constellation Diagram for 4 QAM

ii) Uncoded Simulation Block

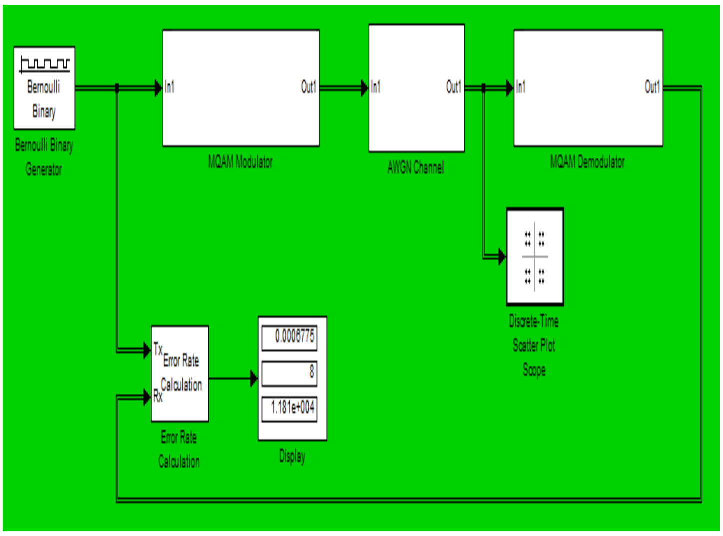

Fig. 9 - Simulation Block

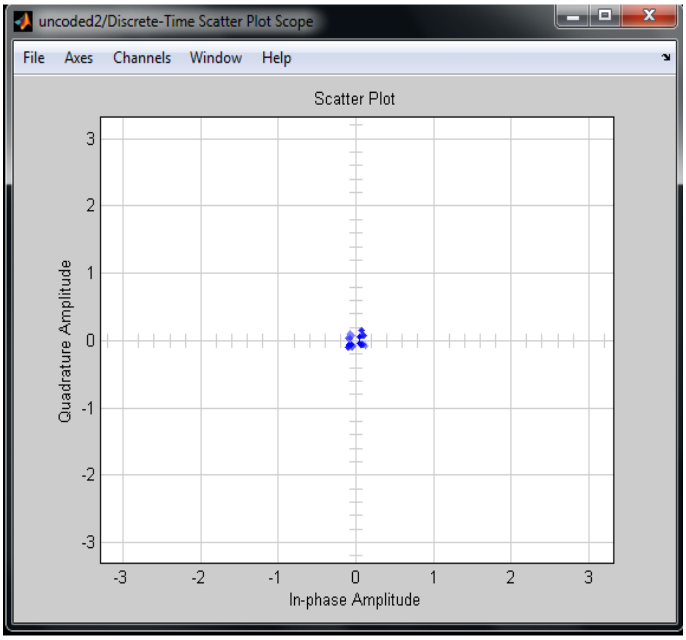

Fig. 10 - Constellation Diagram for 4 QAM

Constellation diagram for coded simulation block in Fig. 9 is smooth without any disturbance (ex: shadow). Constellation diagram for uncoded simulation block in Fig. 10 has disturbance like shadow.

BER performances of uncoded and coded system are obtained. The simulations are carried out by varying the signal-to-noise ratio (SNR), and the BER values are plotted against the channel SNR for different cases as shown in Fig. 11. The simulation results show that the proposed block coding scheme offers a coding gain of about 3 dB at BER of 0.45. It show that peak to average power ratio for coded system is less than uncoded system

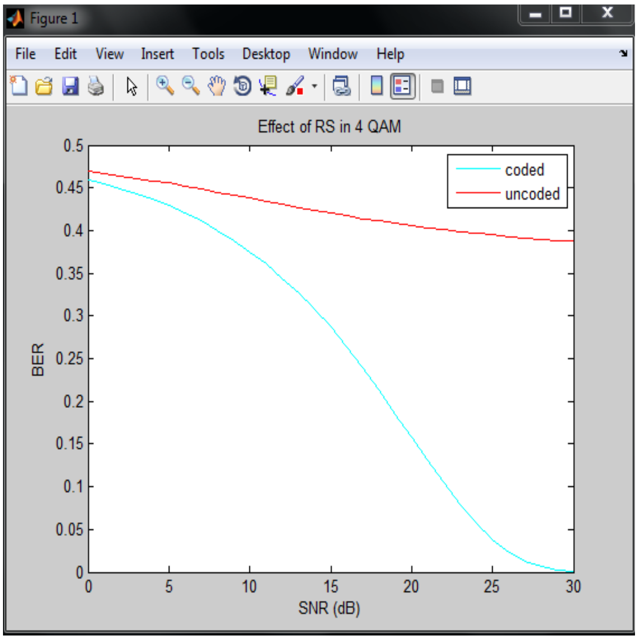

Fig. 11 - Effect of RS in MQAM

The graph in Fig. 12 is plotted using the data. The BER performances of uncoded and coded system are obtained. The simulations are carried out by varying the signal-to-noise ratio (Eb/No), and the BER values are plotted against the channel Eb/No for different cases as shown in Fig. 12. The simulation results show that the proposed block coding scheme offers less peak to average power ratio compared to an uncoded system.

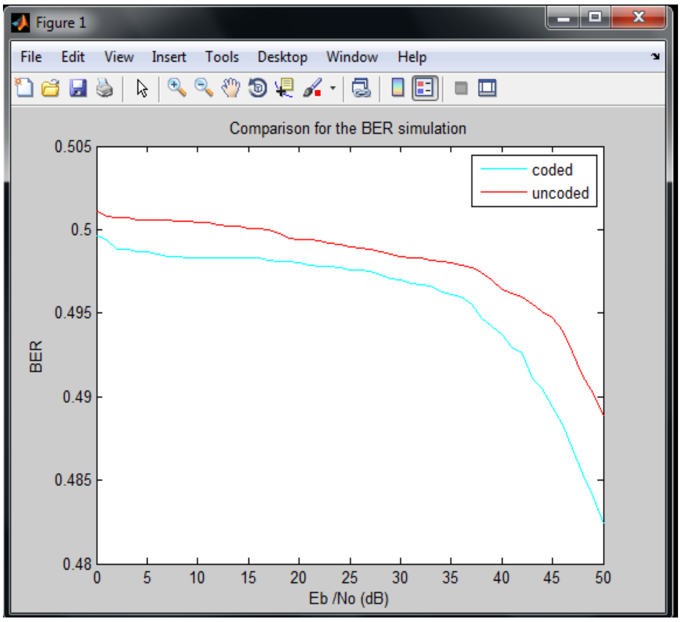

Fig. 12 - Comparison for the BER simulation

The graph in Fig. 13 is plotted using the data. Fig. 13 shows the BER versus SNR performance of different modulation systems. As the SNR increases, the BER decreases. Conversely, as the SNR decreases. Notice that as the SNR decreases, there is a graceful degradation, or roll-off, in channel performance

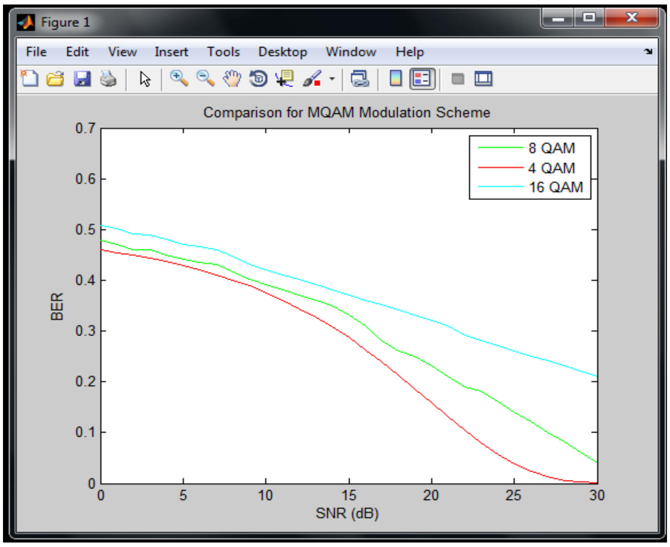

Fig. 13 - Comparison for MQAM Modulation Scheme (BER vs SNR)

5. Conclusion

The current status of the research is that OFDM appears to be a leading candidate for high performance wireless telecommunications. Although due to the fact that it reduces ISI and multipath distortion while giving a very high spectral efficiency, it also exhibits high PAPR that severely limits its popularity. In this report, it has proven that Block Coding can reduce PAPR without much complexity and has the ability for error correction using certain Block Coding technique. Although this work shows that the Block Coding technique can be used to reduce the PAPR in the OFDM system with ease, there are still certain areas for analysis that must be done before being implemented in the real world application design. The Graphical User Interface can be developed in this work to provide enhance analysis function to the users.

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