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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 project, 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.

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## 1. INTRODUCTION

OFDM has a high tolerance to multipath signals and is spectrally efficient making it a good candidate for future wireless communication systems [1]. 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) [2]. 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 [3]. 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 [4]. It is therefore important to minimize the PAPR. 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 [5-6]. In this project, Reed Solomon (RS) technique is applied. In this paper investiagtion of technique to reduce PAPR in OFDM system is discussed using block coding method. The simulation of the PAPR reduction technique in OFDM system using Matlab simulation environment is discussed. The performance of the deisgned system is disucssed for block coding technique and uncoded base on the simulation.

## 2. LITERATURE REVIEW

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 [7]. A block coding scheme has been proposed by T Keller in 2008 [8] to combat the high PAPR exhibits by OFDM system that severely limits its usage in Wireless Local Area Network environment. 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 [9].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. 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 defined by S.B.Wicker [10]. 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. The Ponnampalam demonstrated his efficient decoding algorithm for both non - binary BCH and Reed-Solomon codes [11]. Berlekamp's algorithm allows for the efficient decoding of dozens of errors at a time using very powerful Reed-Solomon codes. Aguilarin 2018 [12] 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. 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. It can also be extended to more complex collections of objects, including certain sets of polynomials with coefficients from finite fields. As mentioned above, Reed – Solomon codes are based on the finite fields so they can be extended or shortened. In this paper,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.

## 3. METHODOLOGY

In this paper, OFDM system consisted of Bernoulli Binary Generator, RS Encoder, Quadrature Amplitude Modulation (QAM) Modulator, RS Decoder, QAM Demodulator, Additive white Gaussian noise (AWGN) Channel and Bit Error Rate (BER) Calculation system are discussed. The proposed simulation models of this project is presented in Figure 1 for the OFDM system with Reed Solomon (RS) code.

### 1) Simulation Model of the OFDM System with RS Code

The Block Coding used in this simulation block is Reed Solomon technique. The data is generated by Bernoulli Random Binary. The data will be encoded by the Reed Solomon Encoder before being mapped by 4 QAM 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 signal will be demodulated by 4 QAM Demodulator. Demodulated signal from 4 QAM Demodulator will be recovered by the Reed Solomon Decoder. BER will be calculated by comparing the transmitted data with the received data. The BER value is shown by the display block. The constellation result is shown by the Discrete- Time Scatter Plot Scope. The data generated was sent in frame form to represent the parallel data in real world application. This will ease the simulation process as the serial to parallel converter was omitted.

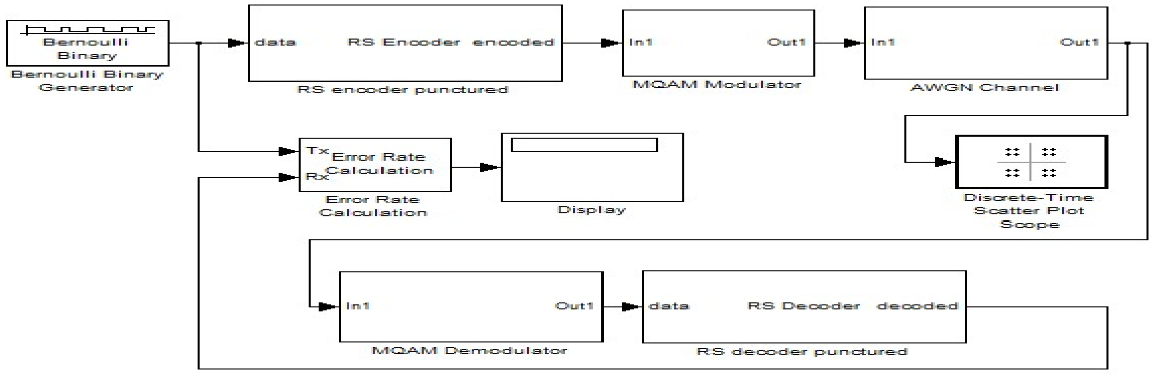



**Fig.1.** OFDM System with RS Code

This subsystem consisted of Bit to Integer Converter, Pad, Integer- Input RS Encoder, Selector, Puncture, Integer to Bit Converter blocks. Figure 3.4 shows the blocks in RS Encoder Punctured Subsystem and Figure 2 shows the simplified RS Encoder Punctured Subsystem.

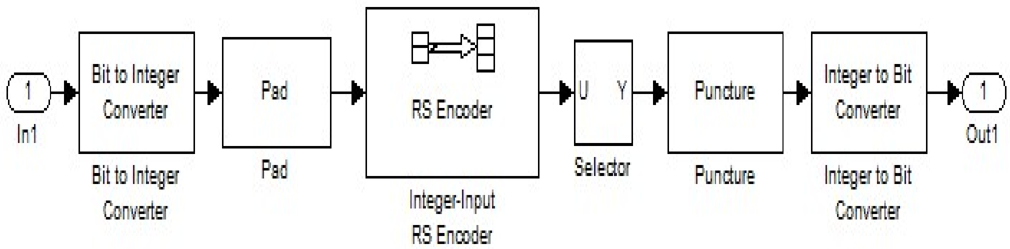
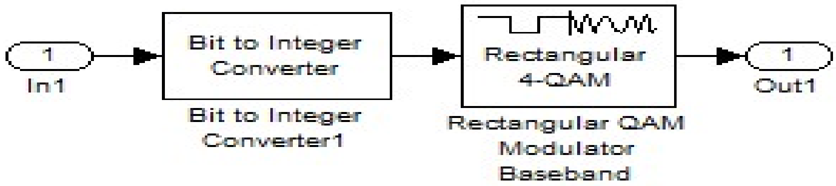



**Fig.2.** Blocks in RS Encoder Punctured Subsystem

This subsystem consisted of Bit to integer Converter and Rectangular 4 QAM Modulator Baseband blocks. Figure 3 shows the blocks in MQAM Modulator Subsystem and Figure 3.7 shows the simplified MQAM Modulator Subsystem.




This subsystem consisted of Transmitter Gain, AWGN Channel, Attenuation, and Receiver Gain blocks. Figure 4 shows the blocks in AWGN Channel Subsystem.

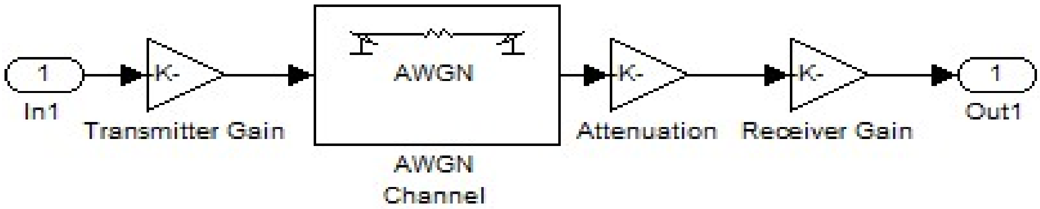



**Fig.4.** Blocks in AWGN Channel Subsystem

This subsystem consisted of Rectangular QAM Demodulator Baseband and Integer to Bit Integer blocks. Figure 3.10 shows the blocks in MQAM Demodulator Subsystem and Figure 5 shows the simplified MQAM Demodulator Subsystem.

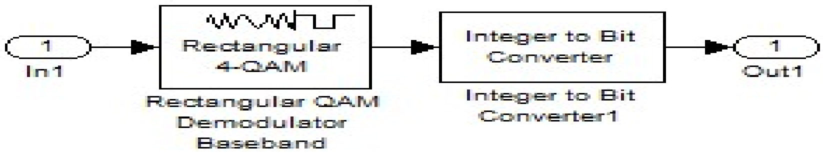



**Fig.5.** Blocks in MQAM Demodulator Subsystem

This subsystem consisted of Bit to Integer Converter, Insert Zero, Pad, Integer- Output RS Decoder, Selector, and Integer to Bit Integer blocks. Figure 6 shows the blocks in RS Decoder Punctured Subsystem.

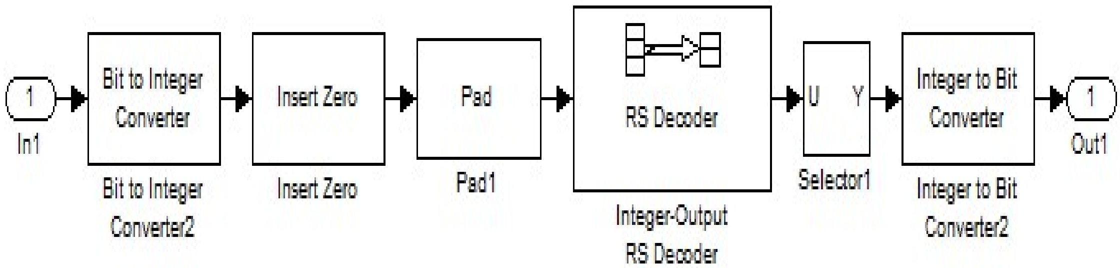



**Fig.6.** Blocks in RS Decoder Punctured Subsystem

In the next, results of the simulation model using MATLAB/SIMULINK. The constellation result for the OFDM System with Reed Solomon (RS) code and general OFDM system is compared. Besides that, BER values are compared between OFDM System with RS code and general OFDM system and also between8 QAM, and 16 QAM modulation scheme.

## 4. RESULTS AND DISCUSSION

The constellation diagram for the OFDM System with RS code has less disturbance and interference. The disturbance and interference are filtered by the Reed Solomon reduction technique. The blue dots in this figure represent the values the signal should produce when transmitting the bit patterns. The distortion or deterioration of the signal will not result in a transmission error with this constellation arrangement. The bandwidth of a QAM signal depends directly on the symbol rate, the number of symbols per second. The relationship of bandwidth to the data rate depends on the number of bits per symbol. QAM uses binary-level modulation of the single frequency carrier wave components, generating an output signal space, or constellation. Each of these message points, or symbols, carries bits of information. The power efficiency is related to the minimum distance between the points in the constellation between the points in the constellation.

Figure 7 shows the 4 QAM Constellation Diagram for the OFDM System with RS Code. This 4 QAM constellation diagram shows symbols, each represented by two data bits that were first gray encoded. The number of the used constellation points in all four quadrants are similar. Hence, average energy computed over one quadrant is same as the energy over all the quadrant.

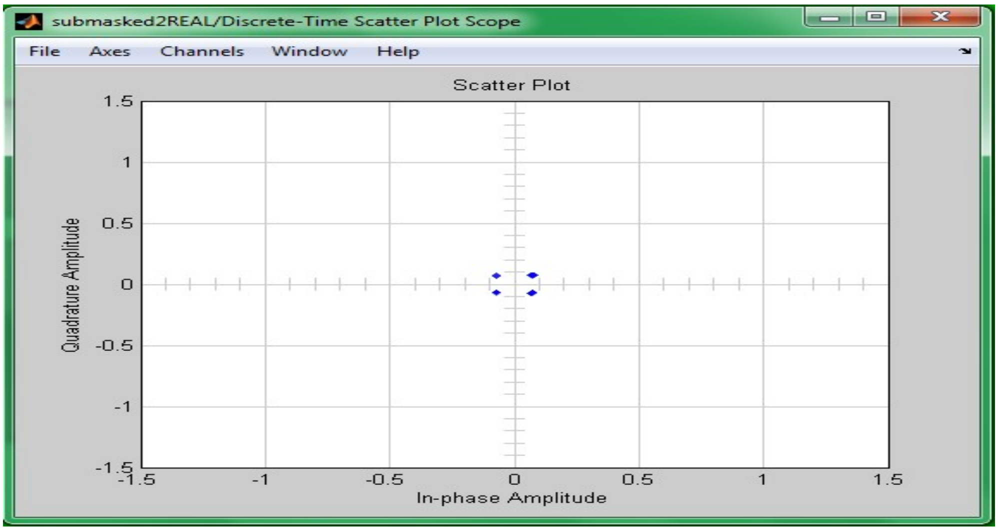



**Fig.7.** 4 QAM Constellation Diagram for the OFDM System with RS Code

Figure 8shows the 8 QAM Constellation Diagram for the OFDM System with RS Code. This 8 QAM constellation diagram shows symbols, each represented by three data bits that were first gray encoded. The number of the used constellation points in all four quadrants are similar. Hence, average energy computed over one quadrant is same as the energy over all the quadrant.

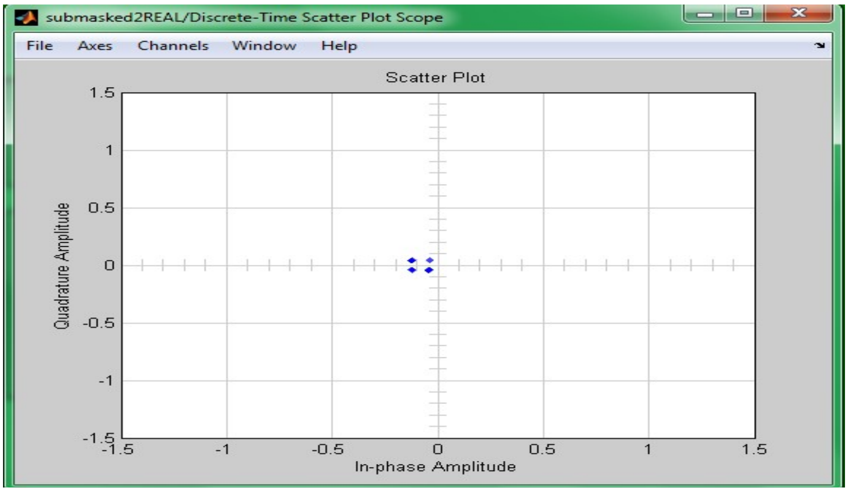



**Fig.8.** 8-QAM Constellation Diagram for the OFDM System with RS Code

Figure 9 shows the 16 QAM Constellation Diagram for the OFDM System with RS Code. This 16 QAM constellation diagram shows symbols, each represented by four data bits that were first gray encoded. The number of the used constellation points in all four quadrants are similar. Hence, average energy computed over one quadrant is same as the energy over all the quadrant.

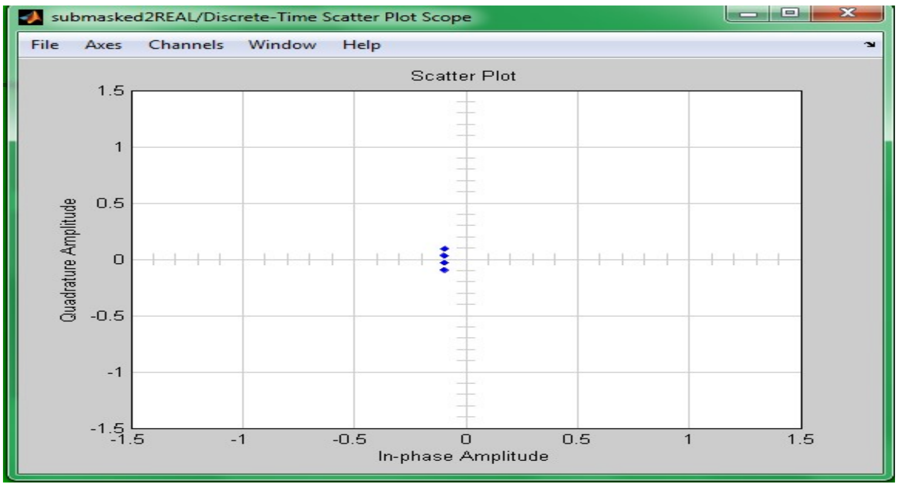



**Fig.9.** 16 QAM Constellation Diagram for the OFDM System with RS Code

1) Comparison for MQAM Modulation Scheme ( BER vs SNR)

Figure 10 shows the BER versus SNR performance of different modulation systems. As the SNR increases, the BER decreases. Conversely, when the SNR decreases. Notice that as the SNR decreases, there is a graceful degradation, or roll-off, in channel performance. The most robust coding modulation scheme, 4 QAM convolutionally encoded QAM modulation. The coding modulation scheme 16 QAM is the highest spectral efficiency. When the SNR ratio is lower than the first intersection point, the target BER cannot be achieved and no information is transmitted. Figure 10 represented Comparison for MQAM Modulation Scheme ( BER vs SNR).

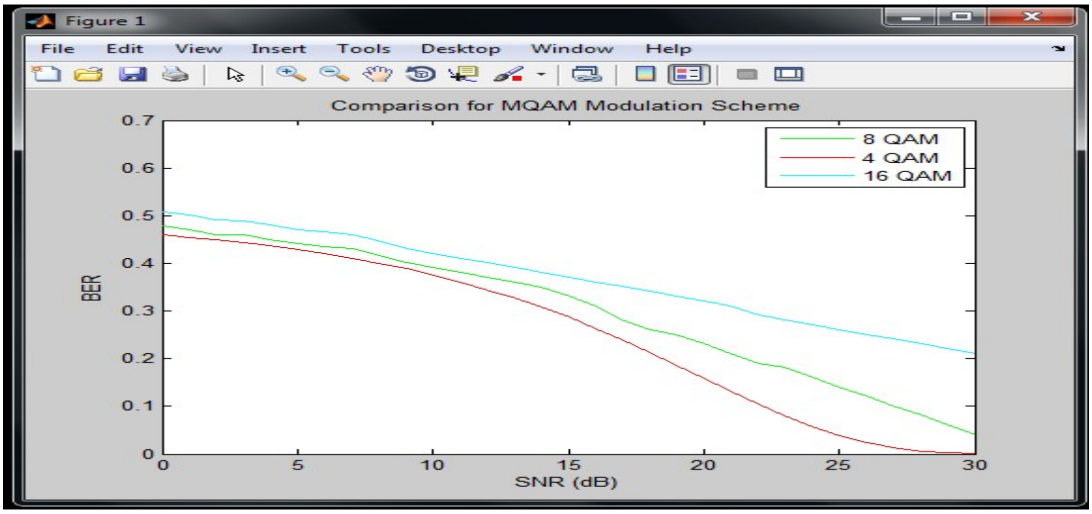



**Fig.10.** Comparison for MQAM Modulation Scheme ( BER vs SNR)

Figure 11 shows that for low noise levels ( SNR large), the BER is extremely small. However, as noise increases beyond a certain threshold level, the BER becomes unacceptable. For example, 4 QAM is reasonably robust for SNR values of 50 dB or more, but for smaller values, the BER quickly approaches 50% bit errors, at which point the signal is entirely lost. The larger values of M, more bits per symbol, require significantly higher SNR to provide comparable bit-error performance. Figure 11 represented Comparison for MQAM Modulation Scheme ( BER vs Eb/No).

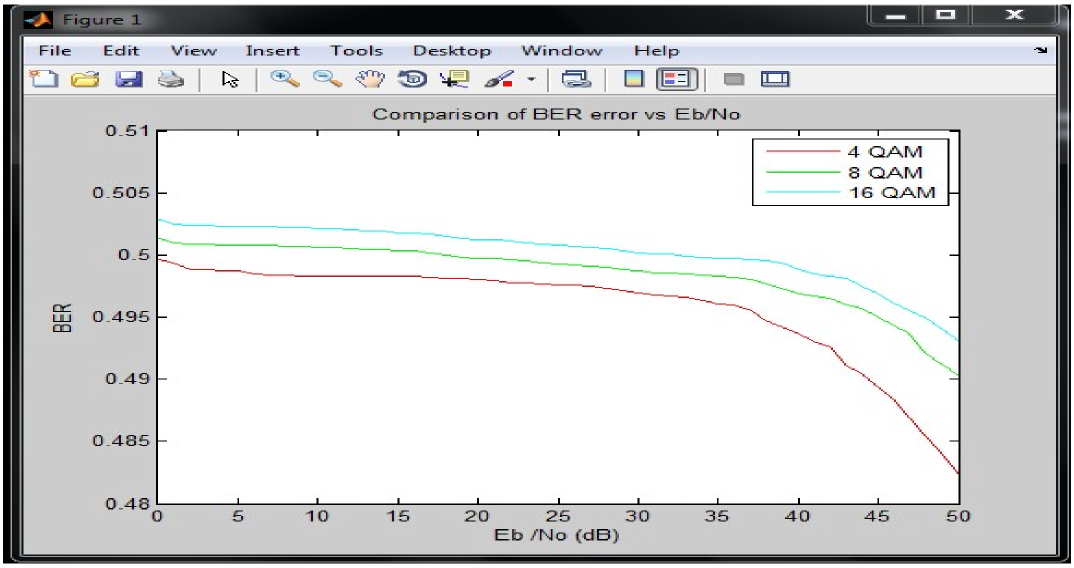



**Fig.11.** Comparison for MQAM Modulation Scheme (BER vs Eb/No)

As observed from the simulation results, it is clearly show that the BER increases as SNR decreases. This point shows that as the signal has more power, it is more resistant to the impact of noise. For the use of different modulation schemes, a huge improvement can be seen using different modulation schemes. The modulation type is 4 QAM, 8 QAM, and 16 QAM. Once the SNR goes below approximately 10 dB, the use of any scheme does not make any improvement to the BER. This study, shows the impact of BER would have on the quality of a broadcast transmission. This is the point for designers to start as they can choose an appropriate BER level and see the impact it would have on the signal.

## 5. CONCLUSION

In this paper, RS code, offers a coding gain of about 3 dB at BER of 0.499. For the OFDM system with RS code, SNR decreases at BER of 0. Based on the simulation, RS code, offers a coding gain of about 2 dB at BER of 0.499. It shows that peak to average power ratio for OFDM system with Reed Solomon (RS) code is less than general OFDM system and for the OFDM system with Reed Solomon (RS) code, Eb/No decreases at BER of 0.497. With that, OFDM promises to be suitable modulation technique for high capacity wireless transmission system and the choice of the future when the wireless networks become the essential part of telecommunications.

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