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# Performance of Linear Block Coded OFDM system in BER and PAPR under different channels

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## ABSTRACT

Orthogonal Frequency Division Multiplexing (OFDM) plays a prominent role in wireless communication technology as multicarrier transmission scheme. The IEEE 802.11a standard uses coded OFDM scheme. This paper is to evaluate the performance of Coded OFDM system in different channels. Linear Block Code (LBC) with Extended Hamming is used to check the improvement of the system performance in BER (bit error rate). The results are obtained for different channels Like Additive White Gaussion Noise (AWGN), Rayleigh and Rician. The DQPSK modulation is used for scheme are comparison purpose. The Differential detection technique is used to avoid the need of a complex equalization process. PAPR for QPSK and DQPSK with conventional and SLM is computed for the comparison purpose.

## Keyword

OFDM, Linear Block Code, BER, PAPR, SLM, AWGN , Rayleigh and Rician Channel.

## 1. INTRODUCTION

OFDM is a very efficient technique for high-speed data transmission used in mobile communication, Digital Audio Broadcasting (DAB), Digital terrestrial mobile communication, Digital Video Broadcasting terrestrial (DVB-T), wireless asynchronous transfer mode (WATM), Modem/ADSL[1,2]. OFDM has many advantages such as High spectral efficiency, robustness in frequency selective fading channels, immunity to inter-symbol interference and capability of handling very strong multipath fading.[3] Recently the advance system such as 3GPP LTE and terrestrial digital TV Broadcasting have been sophisticatedly developed using OFDM technology. Besides the above advantages, however, the bit error occurs in the presence of Doppler frequency shift because of the inter-carrier interference (ICI) in OFDM. OFDM is having major drawback of a high Peak-to-Average Power ratio (PAPR) [4, 5].This high PAPR increases complexity in the Digital Analog converter as well as affects the efficiency of power amplifier. In [6] the sub-block coding scheme for reducing the PAPR of OFDM has low complexity and is found that more than 3dB reduction in PAPR can be achieved when the code rate is ¾. The Hadamard transform sequence to reduce the PAPR problem and it requires no side information to be transmitted to the receiver. Swngwoo et al [8] in their paper proposed new SLM method which rotates the phase of input data after IFFT by using Walsh Hadamard Code. This method has 0.5dB lower PAPR reduced than common SLM and also reduced a computational burden more largely.

OFDM is easy to scheme [7] is to reduce the autocorrelation of the input implement due to efficient FFT (Fast Fourier Transform) algorithm. The implementation of FFT engine mainly depends on the number of input bit size. However the BER performance according to the input bit resolutions of FFT in AWGN channel. Orlandos Grigoriadis, H. Shrikanta Kamat have given the results of the BER as a function of Multi propagation for each set of carriers.[10] The effects of channel estimation error on the BER performance of BPSK and16-QAM modulated OFDM signal in multipath Rayleigh fading channels respectively has been shown. In [11] the high-order modulation like 16-QAM needs more accurate CFO and channel estimation to avoid performance loss. Whereas the Improvement of performance elevation criteria of RS coded OFDM transmission over noisy channel analyzed using simulink. Performance of a flat fading channel using Convolution Interleave that cuts down time delay and memory space increases considerably [12].

In this era the demand of mobile radio communication systems are increasing to provide a variety of high quality services, more features, compactness and other such variety of services to mobile users. Hence modern mobile radio transceiver systems must be able to provide high capacity and variable bit rate information with high bandwidth efficiency, efficient signal power as such[13,14]. Linear block coding is employed to improve the system performance in terms of BER.

Here in this paper Modified SLM method using the standard arrays of linear block codes and DQPSK modulation technique. In earlier paper [9] the same method was used with QPSK modulation whereas we have used DQPSK modulation, our method has shown better performance in PAPR reduction.

## 2. FADING CHANNEL

A signal in mobile communication does not necessarily reach the receiving antenna directly. It gets reflected, diffracted or scattered due to various natural or manmade obstacles in the signal path. Thus the signal undergoes a multipath propagation. This results in infinite number of replicas of the transmitted signal. At receiving antenna the signal reaches as superimposition of the signal which may be constructive or destructive. This affects the amplitude and other such parameters of the signal. Some of the frequencies even get erased due to the reflections, diffractions and other such effects called as selective frequency fading.

The signal along with its replicas is received at receiving antenna in a scattered manner. A time spread occurs between the first and last of the multipath signal at the receiver called as delay spread. In condition when the transmitter and receiver are in motion relatively in a radio transmission frequency of the signal may increase or the frequency of the signal may increase to certain extent before decreasing depending upon the movement. This is the Doppler shift and collectively these are multipath fading. The signal in LOS or short distance propagation is categorize as Rayleigh fading. When the signal undergoes a Non-LOS propagation or large distance propagation is consider to be Rician fading.

## 3. LINEAR BLOCK CODES

Consider an (n, k) Linear code C with parity-check matrix H, where n is the length and k is the dimension of C. Since $Hc^t = 0$ for any codeword c ∈ C, any $X \in e + c$ has the same syndrome as e, that is [15, 16]

$$Hx^t = H(e+c)^t = He^t$$

A binary information sequence is divided into blocks of 4 bits. Each message block is encoded into a codeword C which is 7 bits by a (7, 4) hamming encoder. Hamming codes were designed for correction [17]. The parameters for the family of binary hamming codes are typically expressed as a function of a single integer m≥2 (for m=3, we have a (7,4) Hamming code) not necessarily prime, it is any positive integer. A hamming code on GF(2) has code length $n=2^m-1$, message length $k=2^m-1-m$ , redundancy $n-k=m$ and error connecting capability t=1bit.

### 3.1 Hamming codes

Hamming codes are only single error correcting codes. To improve the error detection and connection capability by adding parity check digit. The resulting code is called the extended binary hamming code. Suppose that c which is 7bits by a [7,4]. Let $\hat{c}$ be the code obtained by adding a single character to the end of each word in c in such a way that every word in $\hat{c}$ has even weight. The parity check matrix of (8, 4) extended hamming code $\hat{c}$ is $\hat{H}$ :

$$\hat{H} = \begin{bmatrix} & & 0 \\ & & . \\ & & . \\ & H & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

According to the formula $S = e\hat{H}^T$ , the syndromes which are corresponding to the non-error and one error patterns could be obtained. And other seven two errors patterns could be obtained from the other syndromes. So the standard array of $\hat{c}$ is constructed. The standard array an [n, k] binary linear code C is a M×N array and for extended array an (8,4) for binary linear code $\hat{c}$ is also M×N array. where $M=2^{m-K}$, $N=2^{K.}$

Another Block code is the Reed-Muller code [11] using the Viterbi algorithm with soft decision it results a very attractive Implementation. As compared in our proposed scheme linear block code is used where decoding part of LBC is very simple structure. So in propose system due to DQPSK modulation technique and simple structure of the decoder reduce the complexity on the receiver side.

## 4. SLM TECHNIQUE

The probabilistic technique is a PAPR reduction technique which includes selective mapping (SLM) and the Partial transmit sequence (PTS) [8,9,19]. The redundancy of the PTS is larger than that of the SLM technique. PTS scheme requires the side information to be transmitted very carefully but in SLM method without explicit side information.SLM technique is an efficient and distortion less scheme. In SLM actual transmit signal lowest PAPR is selected from a set of different signals which represent the same information. PAPR reduction is achieved by multiplying independent phase sequences to the original data. The Combination of DQPSK with SLM not only reduces the complexity at receiver but also it reduces PAPR of OFDM signal. Block diagram of SLM Technique is shown in Figure 1. This SLM technique modified into to reduce PAPR and IFFT block. There is only one IFFT block at transmitter if the sequence which is the lowest PAPR can be found out by a decision algorithm before IFFT.[9] as in Figure2.

## 5. SIMULINK MODEL OF PROPOSED SYSTEM

OFDM system is in Figure 3 which adopts DQPSK modulation,512 subcarriers and linear block codes with extended hamming. During the period of transmitting we adopt the generator matrix G. The code 512 bit makes 1024 possible values by generator matrix.

**Generator Matrix G:**

$$G = \begin{pmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 0 & 1 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{pmatrix}$$

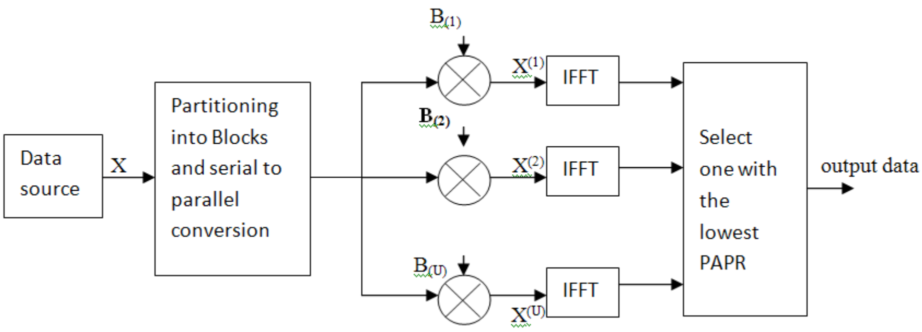



**Figure 1. Block Diagram of OFDM Transmitter with the Conventional SLM Technique**

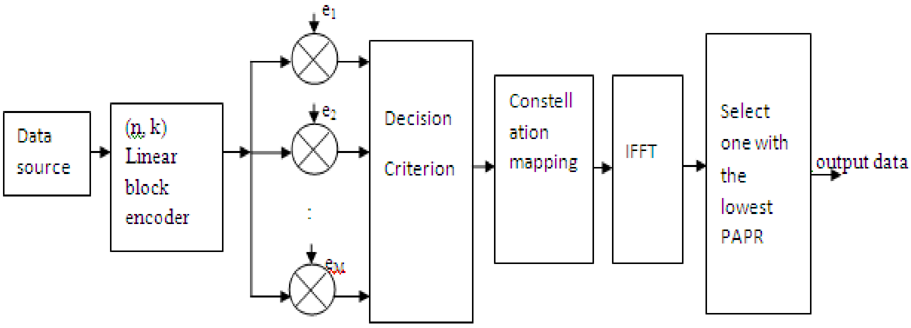



**Figure 2. Block Diagram of Modified SLM Technique**

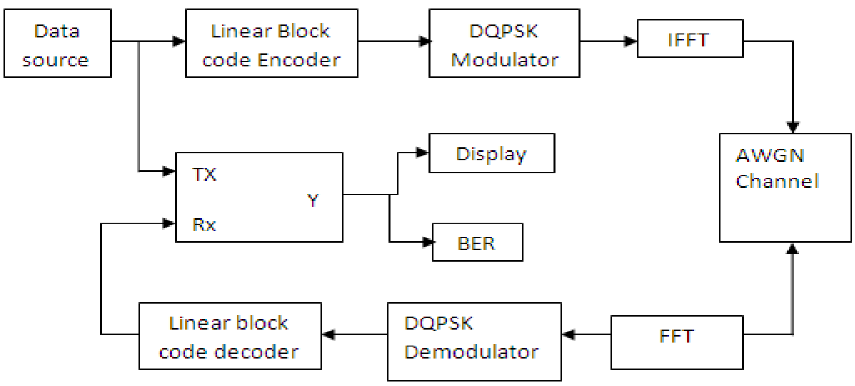



**Fig.3: Simulink Model of linear block code of OFDM system.**

## 6. SIMULATION RESULTS

In this section we analyze the linear block coded OFDM system with DQPSK modulation technique. The decrease in bit error rate performance of OFDM system is investigated in different channels. It is observed that LBC reduces the effect of both fading.

**TABLE 1. Simulation Parameter**

| | |
|---|---|
| Data source | 512 |
| Modulation | DQPSK |
| FFT Size | 512 |
| Coding technique | Linear block Code |
| Message Length | 4 |
| Codeword Length | 8 |
| Channel | AWGN, Rayleigh, Rician |
| Maximum Doppler Shift | 1Hz, 2Hz |
| Rician Parameter | K=1,2,3,4 |

### 6.1 AWGN channel

The data is subjected to Additive White Gaussian Noise (AWGN) with Signal to noise vector (Es/No) is varied according to the modulation techniques used. In complex signals, the AWGN channel block relates Es/No.
Following algorithm for bit error rate it gives good performance under different channels:
N is number of sub carrier, Input: tx and rx ,Y is output.

```
function y = fcn(tx, rx)
error=0;
for i=1:N
  if(tx(i)~= rx(i))
     error=error+1;
  end
```

```
end
ratio=error/N;
y=[error, ratio];
end
```

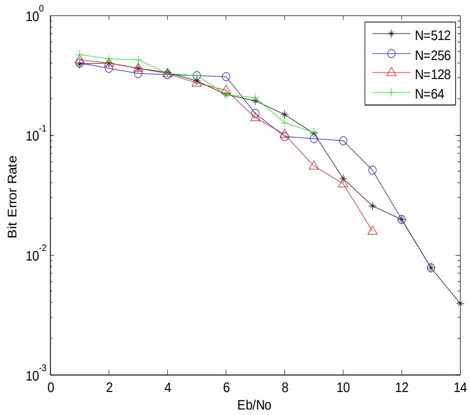



**Figure 4:Bit Error Rate Performance of OFDM for different carriers under AWGN channel using LBC**

When the results were tabulated and a graph was plotted with Eb/No against bit error rate. It is observed that as fig4 the number of carriers are increased the bit error rate of OFDM decreases under AWGN channel using linear block code with extended hamming code. For N=64 the bit error rate $10^{-1}$ dB as the number of carriers is increased the BER decreases to $10^{-2.5}$ dB.Fig 5 is a graph of uncoded and coded of OFDM system under AWGN channel. As compare after LBC coding with extended hamming of OFDM system gives good performance of bit error rate.

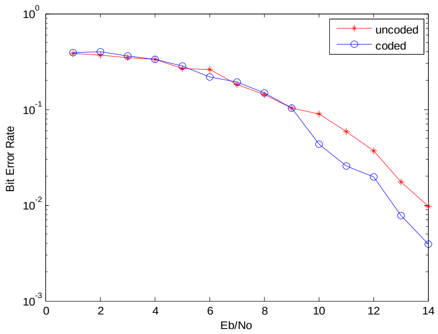
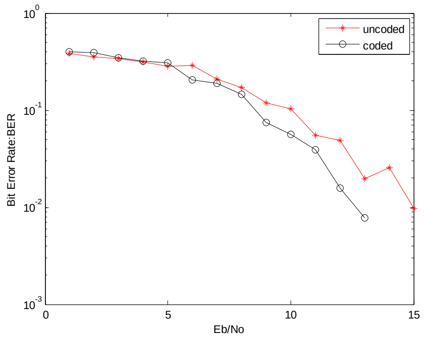
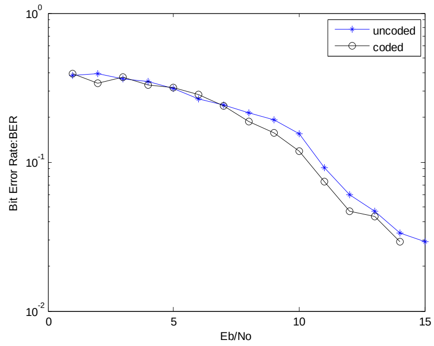



**Figure 5. Bit Error Rate of OFDM under AWGN channel**

## 6.2 Rayleigh channel




(a)




(b)

**Figure 6: Bit Error Rate of OFDM system Under Rayleigh channel using LBC (a)Doppler shift=1hz (b) Doppler shift=2hz**

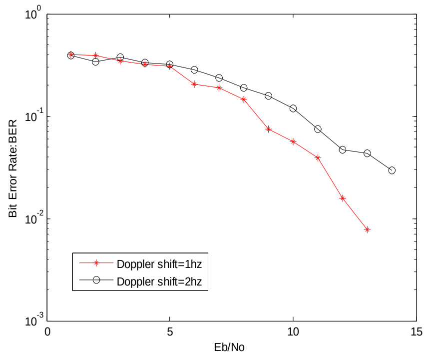



**Figure 7. Bit Error Rate Performance of OFDM system under Rayleigh channel using LBC**

The results obtained under the Rayleigh channel using LBC for bit error rate and Eb/No for different values of maximum Doppler shift are showed in Fig7. Thus it is observed in Fig6 and Fig7 that the bit error rate is better for lower values of Doppler shift.

## 6.3 Rician channel

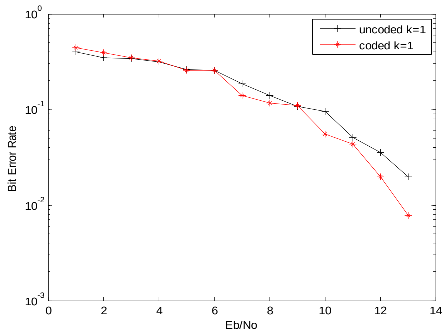



**Figure 8. Bit Error Rate of OFDM system under Rician channel for Doppler shift=1hz**

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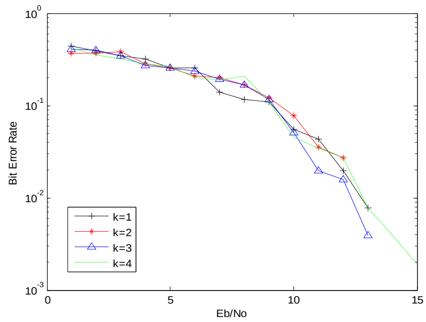


**Figure 9:Bit Error Rate Performance of OFDM system under Rician channel using LBC for Doppler shift=1Hz**

Figure 8 exhibits the results of uncoded and coded OFDM system under Rician channel for k=1.Coded graph shows better performance in bit error rate as compare to uncoded OFDM system. The Figure 9 highlights the results for Rician fading channel. Effect of changing Rician parameter is observed for BER. The results confirmed that for increase in Rician parameter 'k' factor BER performance got better. Results were obtained by using linear block code with Extended hamming and DQPSK Modulation scheme.

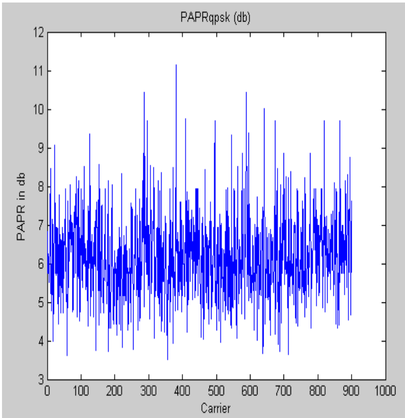


**Figure.10a: PAPR of basic QPSK-OFDM system**

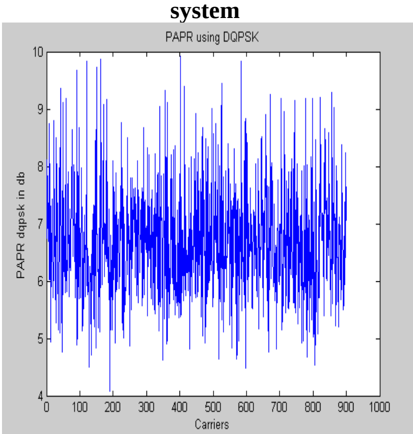


**Figure.10b: PAPR of basic DQPSKOFDM System**

This part contributes for the reduction of PAPR of OFDM system. These results are obtained through the simulation using MATLAB. We have reduced PAPR of OFDM system using Conventional SLM with QPSK and DQPSK modulation scheme. Constellation is chosen as QPSK and DQPSK with 64 subcarriers per symbol. Simulation is carried out in MATLAB for QPSK-OFDM, DQPSK-OFDM with and without SLM & modified SLM Technique.

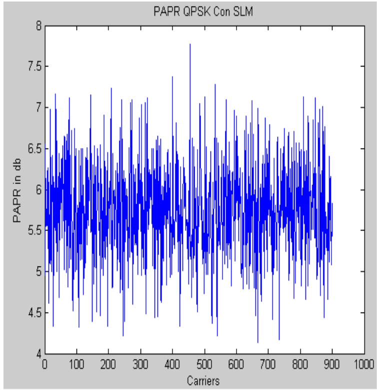


**Fig. 11a: PAPR of QPSK-OFDM system with Conventional SLM.**

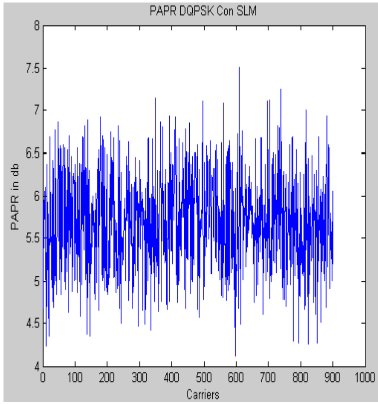


**Fig.11b: PAPR of DQPSK-OFDM system with Conventional SLM**

In Fig.12 With reference [9] the Peak value for the modified SLM technique is 5.5 dB but in our case it is 4.77 dB and average value of PAPR is 2.8dB. This result is better by 0.73 dB. So we concluded that PAPR of Modified SLM is better than conventional SLM.

| **System** | **Maximum PAPR in dB** | |
|---|---|---|
| | **QPSK** | **DQPSK** |
| Basic System (Without SLM) | 11 | 10 |
| Conventional SLM | 7.8 | 7.5 |

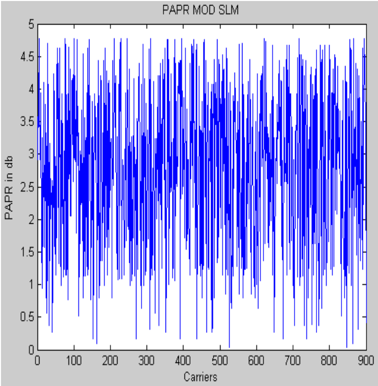


**Figure 12: PAPR of the modified SLM technique**

**7. CONCLUSION**

The proposed scheme has used linear block code with extended hamming to improved the performance in BER and PAPR of OFDM system. Linear block code with Extended hamming is an correcting two error pattern so as to achieve good BER performance as compare to uncoded OFDM system under the different channels. A modified selective mapping technique scheme requires only one IFFT block at the transmitter. The differential detection system is advantageous to reduce complexity, PAPR and gives better performance of OFDM system.

Results of simulation of SLM technique show the PAPR reduction of OFDM system, which further results in high performance of wireless communication. This system provides Modern digital signal processing techniques to improve the reliability of the communication links.

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