OFDM has been recently applied widely in wireless communication systems due to its high data rate transmission capability with high bandwidth efficiency. Error control codes are used to protect information from errors that can occur during transmission. This paper presents an efficient RS-coded OFDM system to improve the performance of OFDM system in terms of PAPR reduction capability and BER reduction capability of the system. To achieve error free communication guard interval is inserted using zero padding. Reed Solomon (RS) codes is one of the most important and best known classes of non binary codes. In this paper we will see how the performance of an OFDM system can be improved by adding RS code to it. This will help to maintain the system performance under a desired bit error rate as there were errors occurring in burst form in OFDM which eventually degrades the efficiency of the system. The proposed technique use the RS coding and µ-law companding. Evaluation of Bit Error Rate (BER) performance and PAPR reduction of OFDM system as a function of code rate and block size are evaluated.

**Keywords:** PAPR, BER, OFDM, RS Code, QPSK.

### I. INTRODUCTION

In today’s scenario there is growing need to transmit information wirelessly, quickly and accurately. So communication engineers have combined various technologies suitable for high data rate transmission with forward error correction techniques.[7] OFDM (orthogonal-frequency-division multiplexing) is a promising technique that is able to provide high data rates over multipath fading channels. According to study there are several benefits of OFDM such as Multipath delay spread, tolerance, Efficient spectral usage by allowing overlapping in frequency domain. Modulation and demodulation are computationally efficient because for this purpose IFFT and FFT are used. In OFDM the bit errors occurs in burst rather than independently and according to previous study the burst errors can degrade the performance of coding. The easiest solution to this problem is to use the strongest code. So we have used the RS codes for this purpose. Inspired by the literature [5,7], an efficient BER reducing technique based on a joint RS coding and µ-law companding is proposed. RS coding improve the BER performance of OFDM system.

### II. REED-SOLOMON CODE

In 1960, Irving Reed and Gus Solomon published a paper in the Journal of the Society for Industrial and Applied Mathematics[6]. This paper described a new class of error-correcting codes that are now called Reed-Solomon (R-S) codes. These codes have great power and utility, and are today found in many applications from compact disc players to deep-space applications. This article is an attempt to describe the paramount features of R-S codes and the fundamentals of how they work. Reed-Solomon codes are non-binary cyclic codes with symbols made up of m-bit sequences, where m is any positive integer having a value greater than 2. R-S (n, k) codes on m-bit symbols exist for all n and k for which

\[
0 < k < n < 2^n + 2
\]

where \(k\) is the number of data symbols being encoded, and \(n\) is the total number of code symbols in the encoded block. For the most conventional R-S \((n, k)\) code,

\[
(n, k) = (2^n - 1, 2^n - 1 - 2t)
\]

where \(t\) is the symbol-error correcting capability of the code, and \(n - k = 2t\) is the number of parity symbols. An extended R-S code can be made up with \(n = 2^n\) or \(n = 2^n + 1\), but not any further.

Reed-Solomon codes achieve the largest possible code minimum distance for any linear code with the same encoder input and output block lengths. For nonbinary codes, the distance between two codewords is defined (analogous to Hamming distance) as the number of symbols in which the sequences differ. For Reed-Solomon codes, the code minimum distance is given by [6]
\[
dmin = n - k + 1
\]

The code is capable of correcting any combination of \( t \) or fewer errors, where \( t \) can be expressed as

\[
t = \left\lfloor \frac{d_{\text{min}} - 1}{2} \right\rfloor = \left\lfloor \frac{n - k}{2} \right\rfloor
\]

where \([x]\) means the largest integer not to exceed \( x \). Equation (4) illustrates that for the case of R-S codes, correcting \( t \) symbol errors requires no more than \( 2t \) parity symbols. Equation (4) lends itself to the following intuitive reasoning. One can say that the decoder has \( n - k \) redundant symbols to “spend,” which is twice the amount of correctable errors. For each error, one redundant symbol is used to locate the error, and another redundant symbol is used to find its correct value.

### III. DISCRETE COSINE TRANSFORM

A DCT is applied to reduce the auto-correlation of the input sequence before the IFFT operation is applied [5]. In this section, review of DCT is done. The formal definition of a one-dimensional DCT of length \( N \) is given by the following formula:

\[
X_k = a(k) \sum_{n=0}^{N-1} x(n) \cos \left( \frac{\pi (2n+1)k}{2N} \right)
\]

For \( k = 0, 1, \ldots, N-1 \)

Similarly, the inverse transformation is defined as

\[
x(n) = c(k) \sum_{k=0}^{N-1} x_k \cos \left( \frac{\pi (2n+1)k}{2N} \right)
\]

For \( n = 0, 1, 2, \ldots, N-1 \)

For both equations (5) and (6), \( c(k) \) is defined as

\[
a(k) = \begin{cases} 
\frac{1}{\sqrt{N}} & \text{for } k = 0 \\
\frac{2}{\sqrt{N}} & \text{for } k \neq 0
\end{cases}
\]

Equation (5) can be expressed in matrix form as:

\[
X_c = C_x x
\]

Where \( X_c \) and \( x \) are both vectors of dimension \( N \times 1 \) and \( C_x \) is a DCT matrix of dimension \( N \times N \). The rows (or column) of the DCT matrix, \( C_x \), are orthogonal matrix vectors. This property of the DCT matrix can be used to reduce the peak power of OFDM signal.

### IV. COMPANDING

Companding is simply a system in which information is first compressed, transmitted through a bandwidth limited channel, and expanded at the receiving end. In this propose work \( \mu \)-law companding is used. In which compression is used at the transmit end after the IFFT process and expansion is used at the reciver end prior to the FFT process. For the discrete OFDM signal given by \( x \) the companded signal \( s \) can be given by

\[
s = C_x \text{sgn}(x) \frac{\ln(1+\mu|x|)}{\ln(1+\mu)}
\]

Where \( \mu \) is the companding parameter.

### V. BIT ERROR RATE OF COMMUNICATION SYSTEM

In digital transmission, the bit error rate or bit error ratio (BER) is the number of received bits that have been altered due to noise, interference and distortion, divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure. Mathematically BER can be defined as follows

\[
\text{BER} = \frac{\text{No. of error}}{\text{Total no. of bits transmitted}}
\]

In a communication system, the receiver side BER may be affected by transmission channel noise, interference, distortion, bit synchronization problems, attenuation, wireless multipath fading, etc. The BER may be improved by choosing a strong signal strength (unless this causes cross-talk and more bit errors), by choosing a slow and robust modulation scheme or line coding scheme, and by applying channel coding schemes such as redundant forward error correction codes.

### VI. PROPOSED HYBRID TECHNIQUE

To reduce the BER of an OFDM signal, a scheme involving the combination of a encoding and companding technique is proposed. coding is used to reduce the bit error rate (BER). In this proposed work, RS Coding is used for generation of multicarrier for OFDM system and for the reduction of BER value of OFDM system. The block diagram of receiver and transmitter of proposed hybrid approach system is shown in Fig.1.
VII. ALGORITHM OF SIMULATION

Here, we measured the performance of the RS coded OFDM through MATLAB simulation. The simulation follows the procedure listed below:

1. Generate the information bits randomly.
2. Encode the information bits using a RS encoder.
3. Use QPSK modulation to convert the binary bits, 0 and 1, into complex signals (before these modulation use zero padding).
4. Perform serial to parallel conversion.
5. Use IFFT to generate OFDM signals, zero padding is being done before IFFT.
6. Use parallel to serial convertor to transmit signal serially.
7. Introduce noise to simulate channel errors. Here, we assumed that the signals are transmitted over an AWGN channel. The noise is modelled as a Gaussian random variable with zero mean and variance $\sigma^2$.
8. At the receiver side, perform reverse operations to decode the received sequence.
9. Count the number of erroneous bits by comparing the decoded bit sequence with the original one.
10. Calculate the BER and PAPR of proposed system and plot it.

VIII. SIMULATION RESULTS

In this section, we present the results of computer simulations used to evaluate BER reduction and PAPR reduction capability of the proposed scheme. The channel was modeled as additive white Gaussian noise (AWGN). In the simulation, an OFDM system with QPSK modulation was considered.

A. PAPR Calculation For Different RS Code

Figure 2 shows the PAPR performance of proposed hybrid technique at different code rate ($r$). The PAPR performance of proposed hybrid technique is degrade by increasing the code rate ($r$), but the effect of code rate on PAPR performance of OFDM signals is very less.

B. BER Analysis for Different RS Code

results are obtain for different RS code, the different code used for this subsection are RS (255, 237), RS (511, 493), and RS (1023, 1005) corresponding to $m=8, 9$ and $10$. No. of bit for the single symbol for encoding.

Fig. 3. BER performance of proposed hybrid technique for different RS code

Figure 3 shows the effect of variable code rate on BER performance of proposed hybrid technique. It is clear from results obtained in this subsection, that for lower value of SNR there is less effect of code rate but for higher value of SNR, lower code rate gives better results.

IX. CONCLUSION

This paper evaluate the performance of RS-coded OFDM system. The simulation has been carried out in terms of reduction of BER and PAPR for the different RS code. The PAPR performance of proposed technique is degrade by increasing the code rate($r$). The results indicate, that for lower value of SNR there is less effect of code rate but for higher value of SNR, lower code rate gives better results. Simulation results indicate that the proposed method gives better results when compared with existing work.

REFERENCES


