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PERFORMANCE AND ANALYSIS OF REED-SOLOMAN CODES FOR EFFICIENT COMMUNICATION SYSTEM

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Abstract-

In wireless communication systems reducing bit/frame/symbol error rate is critical. If bit error rates are high then in wireless communication system our aim is to minimize error by employing various coding methods on the data transferred. Various channel coding for error detection and correction helps the communication system designers to reduce the effects of a noisy data transmission channel. In this paper our focus is to study and analysis of the performance of Reed-Solomon code that is used to encode the data stream in digital communication. The performances were evaluated by applying to different phase sift keying (PSK) modulation scheme in Noisy channel. Reed-Solomon codes are one of the best for correcting burst errors and find wide range of applications in digital communications and data storage. Reed-Solomon codes are good coding technique for error correcting, in which redundant information is added to data so that it can be recovered reliably despite errors in transmission or retrieval. The error correction system used is based on a Reed-Solomon code. These codes are also used on satellite and other communications systems.

Keywords-Reed-Solomon (RS), Galois Field (GF), Generator Polynomial g(x), Bit Error Rate (BER).

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Introduction:

In coding theory Reed–Solomon (RS) codes are cyclic error correcting codes invented by Irving S.Reed and Gustave Solomon. Reed-Solomon codes are block-based error correcting codes with a wide range of applications in digital communications and storage. It has good performance in fading channel which have more burst errors. They described a systematic way of building codes that could detect and correct multiple random errors. By adding t check or parity symbols for ((n, k) code where t= (n-k)/2), to the data, an RS code can detect any combination of up to t erroneous symbols, and correct up to (t/2) symbols. As an erasure code, it can correct up to t known erasures, or it can detect and correct combinations of errors and erasures. Reed-Solomon codes are used to correct errors in many systems like:

- Digital Television
- Storage device
- Wireless communication
- Satellite communication etc.

Many digital communication systems used forward error correction, a technique in which redundant information is added to the signal to allow the receiver to detect and correct error which occurred in transmitted signal. Various types of code are used for this purpose but Reed-Soloman codes give the good compromise in efficiency and time complexity. In an error correcting code, a message M is encoded as a sequence of symbols a_1, a_2. . . a_n, called a codeword. The code incorporates some redundancy, so that if some of the symbols in a codeword are changed, we can still figure out what the original message must have been. Usually, the number of symbols in the codeword is also fixed, so each message carries a fixed amount of data. To encode larger amounts of data, one would break it up into a number of messages and encode each one separately. Blok diagram of channel encoding is given below:

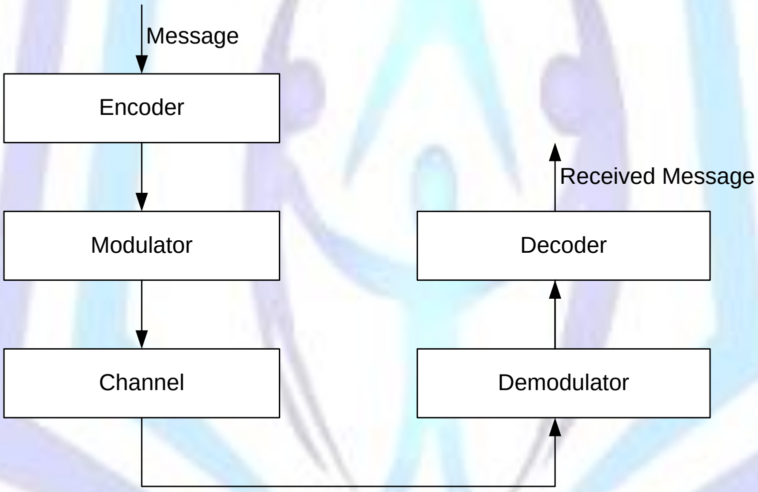

Figure 1: Blok diagram of channel encoding and decoding

The simplest example of an error correcting code is the triple-redundancy code. In this code, the message M consists of a single symbol a, and we encode it by repeating the symbol three times, as aaa. Suppose one symbol in the codeword is changed, so we receive a word baa or aba or aab. We can still recover the original symbol a by taking a majority vote of the three symbols received. If errors result in two symbols being changed, we might receive a word like abc. In that case we can't correct the errors and recover the original message, but we can at least detect the fact that errors occurred. However, with this code we cannot always detect two errors. If the code word was aaa, two errors might change it to something like bba. This received word would be mis corrected by the majority vote decoding algorithm, giving the wrong message symbol b. By repeating the message more times, we can achieve higher rates of error correction: with five repetitions we can correct two errors per codeword, and with seven repetitions we can correct three. These simple-minded error correcting codes are very inefficient, however, since we have to store or transmit three, five or seven times the amount of data in the message itself. Using more sophisticated mathematical techniques, we will be able to achieve greater efficiency.

Literature Review:

Reed-Solomon codes for correcting both errors and erasures are used extensively in space communication links[1], compact-disc (CD) audio system[2], HDTV[3], digital versatile discs (DVD)[4]. By the use of Chinese remainder theorem together with the Euclidean algorithm, an efficient algorithm proposed earlier by Shiozaki [5] can be developed to correct errors and erasures of RS codes. One of the interesting aspects of the correct errors is the Chien search in which codeword can be replaced by only a polynomial, the error-erasure-locator polynomial, called the eratta-location polynomial are determined.

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In [6, 7, 8] authors introduced an orthogonal frequency division multiplexing (OFDM) signaling scheme, where the usual cyclic prefixes are replaced by deterministic sequences, which is known as unique words. Different as in known symbol padding OFDM [9] the unique words are part of the discrete Fourier transform (DFT)-interval, which requires a certain level of redundancy in frequency domain. In [6] authors proposed to generate OFDM symbols by appropriately loading a set of dedicated redundant subcarriers. This process introduces a systematic RS code over the finite field as usual. We optimized the positions of the redundant subcarriers by minimizing their mean energy contribution which leads to an improved bit error ratio (BER) performance. However, this original OFDM concept still suffers from a disproportionately high energy contribution of the redundant subcarriers. In [10] authors solved this problem by introducing a nonsystematic complex number RS code construction. The idea of dedicated redundant subcarriers is abandoned, and the redundancy is distributed across all subcarriers. In [10], the generator matrix has been used to be optimally matched to the linear minimum mean square error (LMMSE) data estimation procedure. Nonsystematic coded of OFDM in combination with LMMSE data estimation has been shown in [5] to significantly to the classical OFDM and the original systematic coded OFDM. The minimization is the mean redundant energy in systematic coded OFDM is in fact also optimum in the sense that the sum of the error variances after an LMMSE data estimation is minimized using different type of PSK.

Problem Statement:

A simple encoding and decoding algorithm for RS code is presented in this paper is based on the fact that the codeword used in Euclid's algorithm is a nonsystematic RS code. It uses the recursive extension to compute the remaining unknown syndromes. Finally, the message symbols are thus obtained by only subtracting all known syndromes from the coefficients of the corrupted information polynomial. In other words, a polynomial division used to evaluate the messaging polynomial. The speed of the new Euclidean-algorithm-based decoding approach is shown to be slightly faster than others algorithms [11]. It can also be utilized to find the errata locator polynomial from Berlekamp-Massey algorithm [12] provided that the message vector has the same format as the one given previously.

Proposed Method:

The algorithm can be described as follows:

1. First the input is applied to the random source. Random M-PSK symbols are grouped into frames.
2. Each frame is applied to the space-time encoder (RS encoder). The RS encoder takes the frame as input and generates codeword pairs for each input symbol simultaneously for all the transmit antennas.
3. Now codeword's are applied to the Pulse shaper. Pulse shaping is used for simulation over frequency selective fading channels and generates channel input.
4. Channel inputs are transmitted through the channel. The signals and channels are modeled in base-band, thus modulation/demodulation operations are not carried out.
5. Channel outputs are applied to the matched filter. Matched filter are used for simulation over frequency selective fading channels and generate received codes.
6. We assume that perfect channel state information (CSI) is available at the receiver. At the receiver, a modified vector RS decoder is used to decode the received codes.
7. Finally, the decoded frames and transmitted frames are applied to the Frame error rate or bit error rate (FER/BER) to calculate the errors.

Result Analysis:

RS code has been widely applied to coded multiple-input multiple-output systems because of its gains in coding and diversity. RS codes are able to combat the effects of correcting and detecting errors. RS code is a bandwidth and power efficient method of communication over fading channel that realizes the benefits of multiple transmit and receive antennas. RS coded M-PSK schemes for a given number of transmit antennas and memory order are designed by applying the design criteria. The RS encoder is used to encode the message, RS decoder uses the decode the message.

In our Implementation we considered the IS-136 standard. In this system, performance is measured by the frame error rate (FER) for a frame consisting of 130 symbols. We also assumed ideal channel state information (CSI) is available at the receiver. We carried out the simulation by MATLAB. Random M-PSK symbols are set in frames as a group, which consists of 130 symbols each. The RS encoder takes the frame as input and generates codeword pairs of each input symbol simultaneously for all the transmit antennas. We modeled the signals and channels in base-band. So modulation/demodulation operations are not carried out. The FER is given by

$$p_e = \lim_{F \to \infty} \frac{F_e}{F}$$

Where F is the total number of transmitted frames and F_e is the total number of erroneous frames received at the receiver. It is impossible to run the simulation for an infinite length of time, so we take F as a very large number. The maximum number of transmitted frame used 10000.

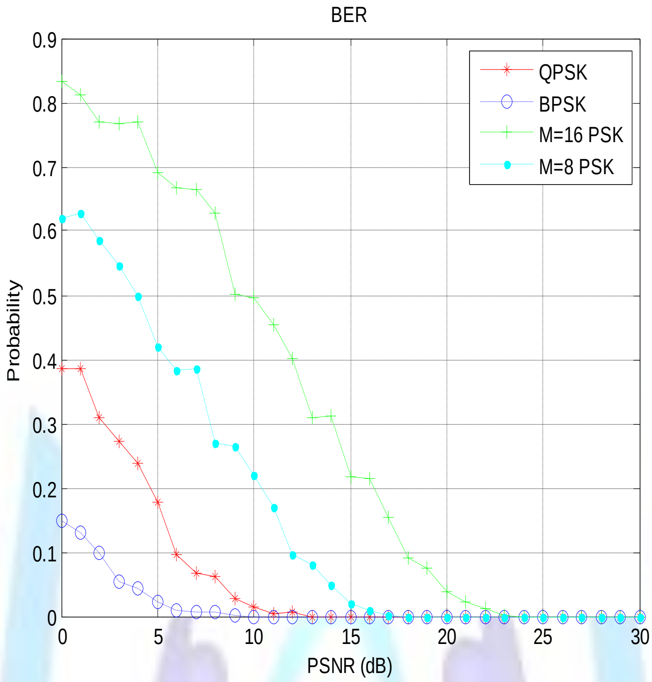

Figure 2: Performance comparisons of the M-PSK RS code over fading channels.

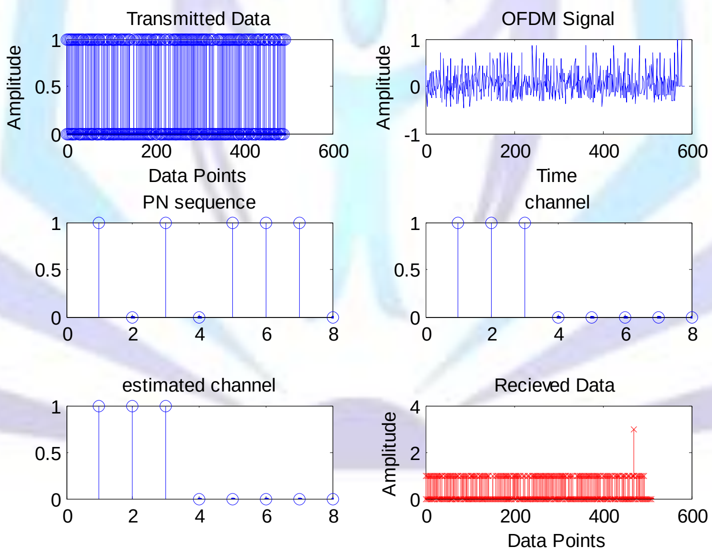

Figure 3: (a) Transmitted data (b) OFDM signal Transmitted data (c) PN Sequence of data points (d) Time channel (e) Estimated channel (f) Received data.

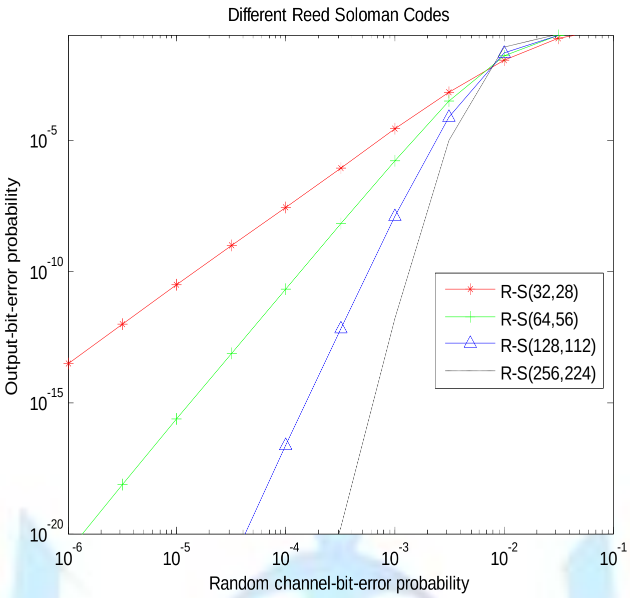

Figure 4: Performance comparisons of the different RS codes.

Conclusion:

RS code has been widely applied obtain gains in coding and diversity. Coding gain and diversity techniques are used to reduce the effect of fading. We have presented analytical performance results for RS codes over spatially correlated channels. Based on this expression, an analytical estimate for bit error probability and frame error probability is computed, taking into account dominant error events. RS codes with orthogonal frequency division multiplexing (OFDM), for high data rate wireless applications OFDM is widely used because of its ability to combat inter symbol interference (ISI). In this work, we used the LMMSE data estimator and the receiver for systematic numbers RS coded OFDM systems. The characteristics of the two estimators are discussed for the AWGN as well as for frequency selective channels. Furthermore, our original code generator matrix design approach for systematic coded OFDM system.

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Author' biography

Sagar Chouksey received BE degree in Electronics and Telecommunication Engineering from Lakshmi Narain College of Technology, Bhopal (M.P) in 2011. He then joined Infosys Technologies Ltd. and held the position of System Engineer from 2011-2013. Now,he is working as a Senior Consultant and Developer at Daffodil Technologies Pvt .Ltd.

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