RESEARCH ARTICLE OPEN ACCESS

Performance Study of RS (255, 239) and RS (255.233) Used Respectively in DVB-T and NASA

Hajri Abdesslam*, El Habti El Idrissi Anas*, El Abbassi Ahmed**,Habibi Mohamed*
** Laboratory Of Electrical Engineering And Energy System. Faculty Of Sciences, University Ibn Tofail Kenitra, Morocco*
*** Laboratory Of Electronics, Instrumentation And Measurement Physics (EIMP). Faculty Of Sciences And Techniques Errachidia, University Moulay Ismail Meknes, Morocco*

ABSTRACT
The error correction codes have a wide range of applications in digital communication (satellite, wireless) and digital data storage. This paper presents a comparative study of performance between RS (255, 239) and RS (255.233) used respectively in the Digital Video Broadcasting – Terrestrial (DVB-T) and National Aeronautics and Space Administration (NASA). The performances were evaluated by applying modulation scheme in additive white Gaussian noise (AWGN) channel. Performances of modulation with RS codes are evaluated in bit error rate (BER) and signal energy -to- noise power density ratio (Eb / No). The analysis is studied with the help of MATLAB simulator to analyze a communication link with AWGN Channel, and different modulations.
Keywords*: Reed-Solomon (RS), Digital Video Broadcasting – Terrestrial (DVB-T), National Aeronautics and Space Administration (NASA), Additive White Gaussian Noise channel (AWGN), Bit Rate Error (BER).*

I. INTRODUCTION

Communication technologies are widely used nowadays. Given the growing percentage of people using these technologies, methods are needed to increase the transmission rate without reducing the quality [1]. One of these methods is the Reed-Solomon (RS) codes that are used to correct errors in many systems like storage devices (CD, DVD, etc…) and digital video broadcasting (DVB)[2].

In the digital communication system, Reed-Solomon codes refer to as a part of channel coding that had to become of great importance to better withstand the effects of diverse channel impairments like noise, interference and fading [3].

The use of an error correction coding to eliminate the need for retransmission of the data is called forward error correction (FEC) [4].The basic concept is to systematically add redundancy to messages at the encoder such that the decoder can successfully recover the messages from the received block possibly corrupted by channel noise.

The objective of this work is to make a Comparative Performance Analysis of Reed-solomon codes used in DVB-T and NASA using noise power flow error rate (Eb/Eo) and the modulation scheme in the channel additive white Gaussian noise (AWGN).

The rest of the paper is organized as follows. Section II describes the Reed-solomon Encoder using and illustrate the decoding process. Section III

presents results and a performance comparison study between RS (255, 239) and RS (255.233) use respectively in the DVB-T and NASA, using the bit error rate (BER) and low signal to noise ratio (SNR). Finally, the concluding remarks are given in Section IV.

II. REED-SOLOMON

2.1 Reed-solomon Encoder

Reed–Solomon codes are an important group of error-correcting codes systems that were devised to address the issue of correcting multiple errors [5]. Those are an important subset of non-binary cyclic error correcting code and the most commonly used codes in practice. Reed Solomon describes a systematic way of building codes that could detect and correct multiple random symbol errors [2]. The codes of Reed Solomon are non-binary BCH (Bose-Chaudhuri-Hocquenghem) codes belonging to the Galois fields GF ($q=2^4$).

These codes are specified as RS (n, k), with m bit symbols, where n is the size of code word length and k is the number data symbols, $n – k = 2t$ is the number of parity symbols.

This means that the encoder takes k data symbols of m bits each, appends $n – k$ parity symbols, and produces a code word of n symbols (each of m bits).

A Reed-Solomon decoder can correct up to t symbols that contain errors in a codeword, where 2t = n-k, as shown in "fig.1"[6], where m is the number of bits in symbol.

$n=2^m-1=k+2t.$ (1)

The minimum distance of a code Reed – Solomon determined by the following "equation 2".

$d_{min}=2t+1.$ (2)

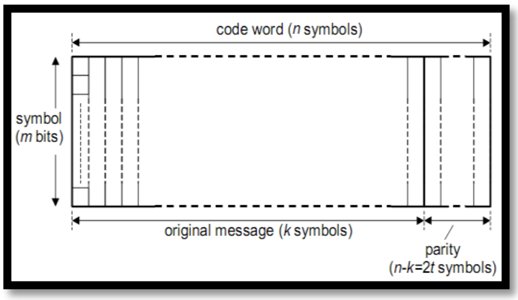

Fig.1: Structure of a Reed-Solomon code word

The following steps do the coding process: [7]

➢ The polynomial Message

The message that needs to be encoded in one block consists of k information symbols. It can be represented as an information polynomial, M(x), of degree k-1:

$$m(x) = m_{k-1}x^{k-1} + m_{k-2}x^{k-2} + \cdots + m_1 + m_0 \quad (3)$$

➢ Forming The Codeword

The process of encoding the message represented in "equation 3". consists of multiplying the information polynomial, m(x), by x^{n-k} and then dividing the result by the code generator polynomial, g(x), Produce a quotient q (x) and a remainder r (x), where r (x) is of degree n-k.

$$\frac{m(x)\times x^{n-k}}{g(x)} = q(x) + \frac{r(x)}{g(x)} \quad (4)$$

g (x) is the generator polynomial of degree 2t, as:

$$g(x) = \prod_{i=1}^{i=2t}(x - \alpha^i) \quad (5)$$

$$g(x) = (x-\alpha^1)(x-\alpha^2)\ldots\ldots(x-\alpha^{2t}) \quad (6)$$

where α is a primitive element in $GF(2^m)$.[8]

The codeword to be transmitted T (x) can be formed by combining m (x) and r (x):

$$T(x) = m(x) \times x^{n-k} + r(x) \quad (7)$$

➢ Physical realization of RS encoder [9]

It is found that make the realization of a RS encoder requires two operators:

- Shifting operation
- Division operation

Both operations can be performed grace shifts registers and multiplexers. "Fig.2" shows the general diagram of the RS encoder.

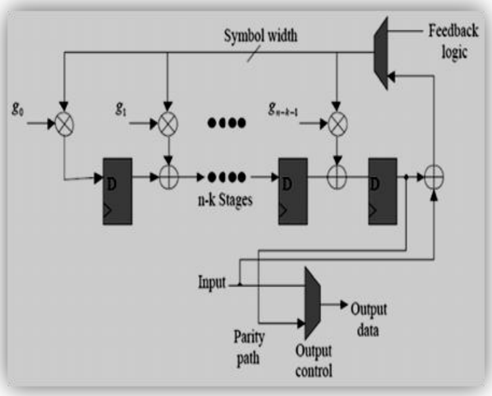

Fig.2: Scheme of a Reed-Solomon encoder

2.2 Reed-solomon Decoder

The Reed-Solomon decoding is an operation, which is used to detect and correct errors, produced by the transmission channels [6].T(x) and R (x) represent respectively transmitted codeword polynomial and received codeword polynomial [10].

The transmitted code word polynomial can be corrupted by channel noise during transmission consequently, the received code word can bewrite as

$$R(x) = R_{n-1}x^{n-1} + R_{n-2}x^{n-2} + \cdots + R_1 + R_0$$

$R(x) = T(x) + E(x)$, Where E (x) the error polynomial.

The Reed-Solomon decoding usually follows the following stages in the decoding cycle [11]:

a. Syndrome Calculation.
b. Determine error-location polynomial.
b. Solving the error locator polynomial.
d. Calculating the error Magnitude.
e. Error Correction

a) Syndrome calculation

The first step in decoding the received symbol is to identify the data syndrome. The generator polynomial divides the input symbols received. The remainder must be zero. The parity is placed in the codeword to ensure that code is exactly divisible by the generator polynomial. If there is a remainder in the division, then there are errors. The remainder called the syndrome.

b) Determination of error-locator polynomial

After counting the syndrome polynomial, next step is to calculate the error values and their respective locations in code. This stage involves the solution of the 2t syndrome polynomials from the previous stage. These polynomials have v unknown terms, where v is the number of unknown errors prior to decoding.

c) Solving the error locator polynomial:

Once the ability to determine the error locations and values of a polynomial error, the next step is to evaluate the polynomial error and get the roots. The roots that obtained will now point to error location in the received message. RS decoding generally implements the Chien search algorithm to implement the same.

d) Calculate error value

Once the errors are located, the next step is to use the syndromes and the error polynomial roots to derive the error values. Forney's Algorithm is used for this purpose. It's an efficient way of performing a matrix inversion, and it involves two main stages.

e) Error correction

If the error symbol has any set bit, it means that the corresponding bit in the received symbol is having an error, and must be inverted. To automate this correction process each of the received symbols is read again, and at the each error location the received symbols are XORed with the error symbols. Thus the decoder corrects any errors as the received word is being read out from it.

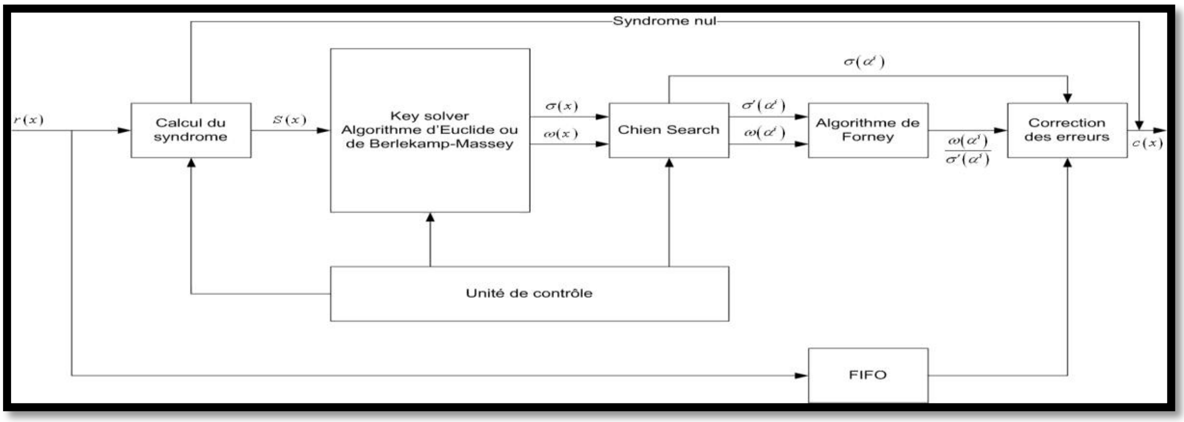

Fig.3: different steps of a Reed-Solomon decoder.[12]

III. PERFERMANCE STUDY AND SIMULATION RESULTS

The advantage of using Reed-Solomon code is that The Coding rate is very high for Reed-Solomon code so it is suitable for many applications including storage and transmission. As for the decoded the advantage of using Reed-Solomon codes is that the probability of an error remaining in the decoded data is (usually) much lower than the probability of an error if Reed-Solomon is not used. This is often described as coding gain .

3.1 Performance of RS (255, 239) in DVB-T

To analyze the performance using the bit error rate term (BER) as shown in "fig.4", two codes are presented in this "fig.4" RS (15, 11) and RS (255, 239). The channel and the modulation type are respectively AWGN and PSK where the order of modulation is equal to 2.

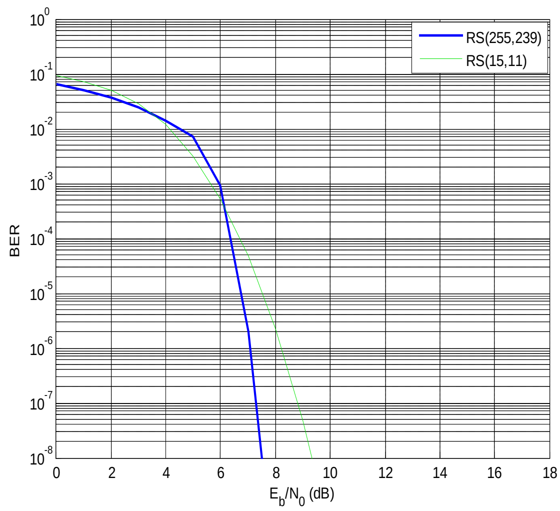

Fig.4: comparison of Performance of RS (15, 11) and RS (255, 239) .

"Fig.4" shows the performance of two codes: RS (15, 11) and RS (255, 239). 15 is one of length, and 255 is the other length. Clearly shows in the diagram when the signal power increases the error rate decreases, as the signal rises above the noise table level present in the channel. It is observed that the coding gain is 1.1 dB for a BER = 10^{-5} when the length of the code word changes from 15 to 255. However, when the code word length increases, the complexity of calculating and implementation increases too.

3.2 Performance of RS (255.233) in NASA

To analyze the performance using the bit error rate term (BER) as shown in "fig.5", two codes are presented: RS (15, 11) and RS (255, 233). The channel and the modulation type are respectively AWGN and PSK where the order of modulation is equal to 2.

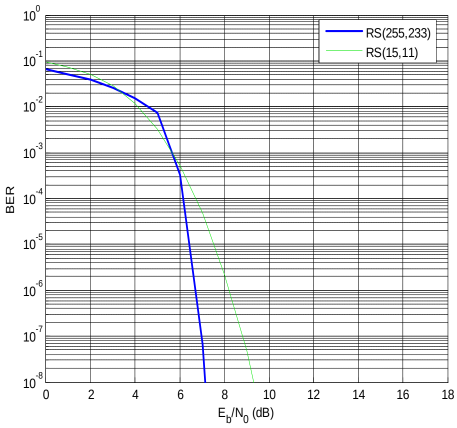

Fig.5:comparison of Performance of RS (15, 11) and RS (255, 233).

"Fig.5" shows the performance of two codes: RS (15, 11) and RS (255, 233). One of length 15, and the other of length 255. Clearly as shown, by the diagrams as the signal power increases the error rate decreases, as the signal rises above the noise table level present in the channel. It is observed that the coding gain is 0.8 dB for a BER = 10^{-5} when the length of the code word changes from 15 to 255. However, when the code word length increases, the complexity of calculating and implementation increases too.

3.3 Comparative of performance between RS (255, 239) and RS (255.233)

To analyze the performance using the bit error rate term (BER) as shown in "fig.6", two codes are presented: RS (255, 239) and RS (255, 233. The channel and the modulation type are respectively AWGN and PSK where the order of modulation is equal to 2.

The "fig.6" shows the performance of two codes: RS (255, 239) and RS (255, 233). One of number data symbols 239, and the other of number data symbols 233. Clearly as shown by the diagrams as the signal power increases the error rate decreases, as the signal rises above the noise table level present in the channel. It is observed that the coding gain is 0.36 dB for a BER = 10^{-5} when the number data symbols of the code word changes from 233 to 239. However, when the code word length increases, the complexity of calculating and implementation increases too.

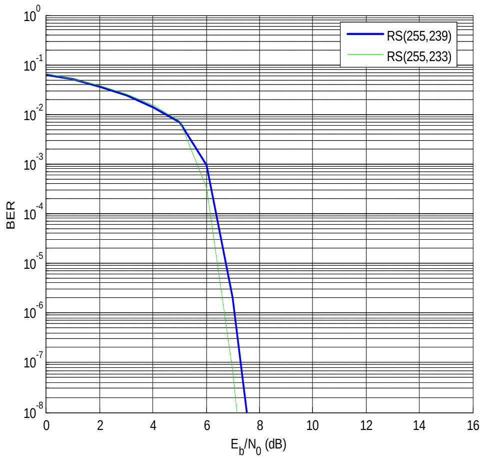

Fig.6:comparison of Performance of RS (255, 239) and RS (255, 233)

IV. CONCLUSION

Through this article, we present deep and clear understanding of the encoder and decoder of Reed-Solomon code, so we making them simpler and easier to understanding and implementing by using DVB-T and NASA. This study addressed the performance of Reed-Solomon code in terms of bit error rate (BER) and the noise power density ratio of the signal energy (Eb / No).

ACKNOWLEDGEMENTS

This work was supported by the Laboratory of Electrical Engineering and Energy System, Faculty of Science, University Ibn Tofail Kenitra,Morocco.

REFERENCES

[1]. R. HUYNH, G. Ning, and H. YANG, A Low Power Error Detection in the Syndrome Calculator Block for Reed-Solomon Codes: RS (204,188), Tsinghua Science & Technology, 14(4) , 2009, 474-477.

[2]. P. SHRIVASTAVA, and UP. SINGH, Error detection and correction using reed-solomon codes, International Journal of Advanced Research in Computer Science and Software Engineering, 3(8), 2013,965-969.

[3]. D. Subhashree ,VHDL implementation of reed-solomon coding, National Institute of Technology Rourkela, 2011.

[4]. H. LEE, High-speed VLSI architecture for parallel Reed-Solomon decoder, IEEE

transactions on very large scale integration (VLSI) systems, 11(2), 2003,288-294.

[5]. S.Sudhakaran, and P. Ramesh, Design and Imlementation of Reed Solomon (16,8) Decoder, International Journal of Current and Engineering Technology, 3(8), 2013,1990-1993.

[6]. C.K.P. Clarke, Reed-Solomon error correction, BBC Research and Development British Broadcasting Corporation, WHP 031, 2002.

[7]. H. LEE, A high-speed low-complexity Reed-Solomon decoder for optical communications, IEEE Transactions on Circuits and Systems II: Express Briefs, 52(8), 2005, 461-465.

[8]. L. Borkar. Harshada, and V. N. Bhonge **,**Review: Design And Implementation Of Reed Solomon Encoder And Decoder, SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE) ,2(1) , 2015,,29-33.

[9]. Reed-Solomon (RS) Coding Overview, VOCAL Technologies, Ltd., Rev. 2.28n, 2010.

[10]. G.Lakshmi Priya, and A.Raghuram , VLSI Implementation of Low -Complexity Reed Solomon Decoder , International Journal of Engineering and Technical Research (IJETR) 3(11), 2015, 2454-4698.

[11]. V .J. BABREKAR, S. V. SAKHARE, Review of FPGA Implementation of Reed-Solomon Encoder-Decoder, International Journal of Computer Applications, 87(8), 2014,16-19.

[12]. S. LIN, and D. J. COSTELLO, Error control coding 2nd edition. 2004.