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BER Staging of Coded-OFDM with Binary and Non-Binary Coding Techniques for LTE Uplink Transmission

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ABSTRACT

The OFDM is a multicarrier communication in the current day mobile communication with LTE uplink transmission. In spite of the technological development it also brings some major challenges due to the random behavior of the wireless environment. In particular, the BER performance severely decays with the fading characteristics of the wireless channel. Forward error correction techniques play a key role to detect and correct the transmission errors. Hence, there is a need to study the performance of these systems under various network conditions. In this paper, the BER performance analysis of the OFDM wireless transmission has been carried out using RS and BCH codes. Adaptive modulations like M-PSK and M-QAM have been used for computer simulations. It is shown that RS coded OFDM system performs well under burst error channels and BCH codes are able to provide better error correction capability under lower order modulations. The comparison analyzes has been done to highlight the importance of these codes under wireless environments.

Key words: BCH code, Bit Error Rate, MDS, OFDM, RS code, Signal to Noise Ratio.

1. INTRODUCTION

The OFDM is a basically innovative MCM technique which has mutually orthogonal carriers to each other over a limited interval. Every carrier involving a pair of signal is noted as a sub-carrier and which is considering OFDM thru 'N' sub-carriers. The available bandwidth transmit (W) is equally spaced amongst the 'N' sub-carriers. Let us say the subcarrier bandwidth allocated to W/N Hz. The subcarrier spacing is also W/N Hz which is space between adjacent sub carriers. An OFDM has been widely used in ASDL, WLANs because of its efficient data rate and applied in real time scenario. The OFDM very much suffers from high Maximum to Expected Power Ratio (PAPR) and results heavy nonlinearity in power amplifier which will degrade total enactment. The performance related to OFDM can be computed by the parameter is popularly known as Bit Error Rate (BER).

The obtainable BER is always based on the (SNR) and the possible optimal solution is required to improve the enactment. The BER is lessen at suitable SNR in dB (which is lowest to fix because of its fade). In such a practical situations Noise is more so SNR likely to reduce but usually more SNR indicating less noise. Here, needed to get suitably BER vs SNR to reach the more and more compact but not to be degrade. The BER can minimal with suitable chosen modulating factors to maintain the best level in uplink communications (as per authors the permissible/ acceptable BER is 10-3/10-4) and which will be decided thru proper selection of equalizers.

Figure 1 shows three orthogonal sub-carriers over symbol duration (T sec). That the fsub-carrier are f0= 1/T Hz, f1 =2/T Hz and f2 =3/T Hz. It note that, possible combinations of these three frequencies are orthogonal over T sec, written as (1/ T, 2//T, 4 /T), (1 /T, 3 /T, 4 /T), (1/ T, 5 /T, 9/ T) and so on. However, all combinations of these frequencies are not suitably required the bandwidth efficient [1], [2].

Mathematically, if $\{\tilde{X}(\mathrm{k})\}$ symbol sequence which signifies a N –the complex modulating signals, and the complex baseband modulated OFDM symbol is given as

$$\tilde{x}(t) = \frac{1}{N}\sum_{k=0}^{N-1}\tilde{X}(\mathrm{k})e^{j2\pi k f_0 t},$$
$$0 \le t \le T \ and \ k = 0,1,.......,(\mathrm{N}-1) \qquad (1)$$

Let $\tilde{X}(\mathrm{k})$ be the kth symbol modulate over the kth subcarrier and is provided the inter-subcarrier spacing. As designated, the orthogonal subcarriers occupy the zero crossing of spectral positions of other subcarriers.

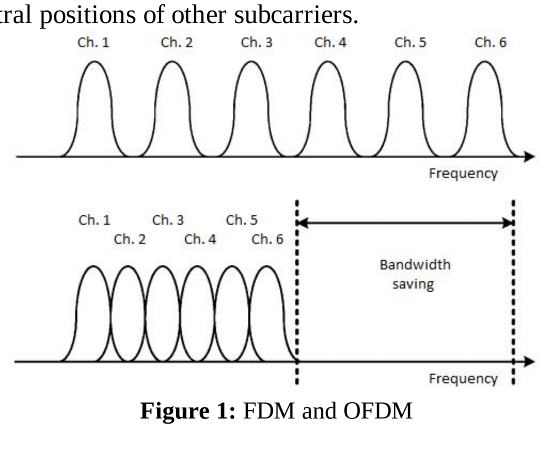

Figure 1: FDM and OFDM

Further, In Eq. 1 satisfies the OFDM modulated signal can be made by simple Inverse DFT (IDFT) which can be executed resourcefully as N-point Inverse FFT (IFFT). From the Eq. 1 the modulated signal is uniformly sampled with an interval T/N , then nth sample of the OFDM signal is derived as:

$$\tilde{x}\left(\mathrm{n}\frac{T}{N}\right) \equiv \tilde{x}(n) = \frac{1}{N}\sum_{k=0}^{N-1}\tilde{X}(\mathrm{k})e^{j2\pi k f_0 nT/N}, \quad 0 \le n \le (N-1) \qquad (2).$$

Likewise, at the receiver side, an N-point FFT is performed which is equivalent demodulation of OFDM signal. This makes very easy comfortable to design and employment of OFDM modulator and demodulator with very convenient. [1], [2].

The 4G based on IEEE standard synchronous broadcasting of voice and data is feasible on LTE so that data rate is considerably improved. Key features include data rate of 1Gbps, diminished latency for special application, HD video conferencing and online gaming, voice over LTE network using internet protocols. The demerits are 1) expensive hardware 2) costly spectrum 3) high end mobile density and 4) time consuming wide deployment.

Table 1: Cellular standards for mobile generations

Generation	Standard	Transmission Rate	Application
2G	GSM, IS-95(CDMA)	10 kbps	Voice, low data
2.5G	GPRS, EDGE	50-200 kbps	Voice, low data
3G	WCDMA/UMTS CDMA 2000	384 kbps	Voice, low data Video call & conf.
3.5G	HSDPA/HSUPA	5-30 Mbps	Video call & conf.
4G	WiMAX, 3GPP LTE	100 -200 Mbps	Online gamming HDTV
4G	LTE-Advanced	>1 Gbps	High Data
5G	5G NR, LTE-U	>100 Gbps	High Data

The 5G is to deliver ultrafast internet and multicore segment. It will be based on mm wave and unlicensed spectrum. Complex mode technique will help internet of things; key features are a) 10Gbps b) low latency c) controllers d) high segments e) beamforming for efficiency f) forward compatibility network and g) cloud band improvement [1], [2].

This paper considering the channel coding techniques categorized into Linear Block codes (Hamming), cyclic codes (CRC), BCH codes, RS codes, Golay codes, Reed Muller codes, LDPC codes etc.

The authors say that binary vs non-binary codes used in OFDM scenario applicable in mobile communications. The background of binary and non-binary coding theory was developed by two family of people based on BCH codes and (Raj Bose, Dijen Ray-Chaudhuri and Alexis Hocquenghem) and RS codes (Irving Reed and Gustave Solomon). Together kinds of these codes are widely used to share many common features. For instance, the codeword length is 2^m- 1 (typically m = 8, in most cases) for both codes. The differ in both cases is m-bytes for RS code and bits for BCH codes whereas algebra is ready for both cases is Fq with $q=2^m$. The RS codes improving reliability since its burst error correction capability.

Then it decides on the huge errors, we must find their locations. The errors can be computing via solving a system of linear equations.

This paper organized as section II discusses about binary and non-binary codes. The section III proposes the OFDM transceiver structure with suitable codes. The BER simulations are performed for BCH and RS codes in Section IV. Finally it concluded and given future scope in section V and VI.

2. RELATED WORK

The coding techniques are categorically two, that source coding and channel coding strategies. Here, in this we discuss more emphasis on coding techniques to detect and correct the errors of their performance as soon as the data is communicated over noisy channels. An introduction to error control coding, which is a vast and exciting area within coding theory is called channel coding. The error control coding schemes we will use a in-built redundancy mechanism to recover from errors.

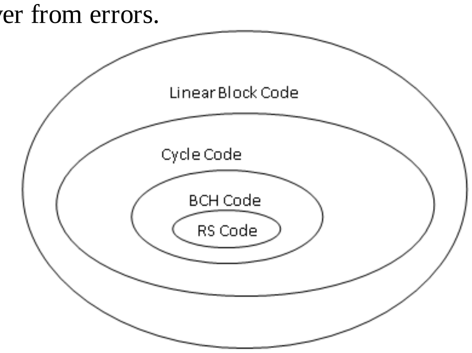

Figure 2: Subclasses of Coding Theory

Information source has an inbuilt redundancy which is removed or reduced by the source encoder and then we add redundancy in a known manner using this channel encoder also called as error control coding. And then we must send the bit stream over the channel and to do, so we need a modulator. Do that the message is sent over the channel where we have our friend or enemy depending upon how you look at it the noise, the noise introduces the error. Now we demodulate and then go for the channel decoder which is a reverse of the channel encoder it figures out the errors and tries to recover from the errors. And then we pass on the error free or seemingly error free bit stream to the source decoder which is the opposite effect of the source encoder. The most important character in this play is this noise, without the noise we have no need for this channel encoder and channel decoder [3]-[6], [16]-[17].

The subclasses of block codes are discussed in the above Figure 2 that is Linear Block codes, cyclic codes, BCH codes, RS codes. The Figure 3 represents here error control behavior in wireless environment.

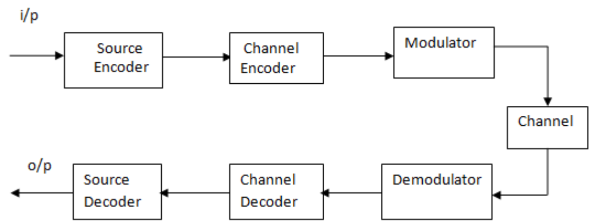

Figure 3: Typical error control coding block

2.1 Binary Primitive BCH Codes

The BCH codes has multiple error correction capability and the comfort encoding and decoding process. BCH codes which stands for authors Bose-Chaudhuri-Hocquenghem codes are over non binary fields. So we have GF(q) over which BCH codes are defined and they can correct several errors, burst errors and are pretty strong in the error correcting capability.

A primitive component, primitive polynomials, factorization, Extension field GF(q^m), Galois field GF(q), element 'q', so if you remember Galois field GF(q) may have at least one element α such that every field except of course, the '0' element can be expressed as a power of α. The polynomials degree exist over Galois field since a primitive can easily construct an extension field suitably [3]-[6], [16].

Factorization of (x^{q-1}-1): So that,

$$X^{q-1}-1 = (x-\beta_1)(x-\beta_2)....(x-\beta_{\theta-1}) \tag{3}$$

Where, $\beta_1,\beta_2,\ldots\ldots,\beta_{\theta-1}$ denote non -zero field essentials in the Galois field.

Extension field :

The Extension field GF(q^m) from the Galois field GF(q).

Assume that primitive length is n =q^m-1.

Let us consideing a factorization as in that,

$$X^n-1 = x^{q^m-1}-1 = f_1(x)\, f_2(x)....f_p(x) \tag{4}$$

For each non -zero component respect to GF(q^m) is reaches to zero component w.r. to $x^{q^m-1}-1$.

For all non-negative integer m(m $\geq$ 3) and tec(tec<2^m-1), acceptable BCH code has parameters:

The Block length: n=2^m-1,

The Parity-check digits: $n-k \leq mt_{ec}$,

The Minimum distance: $d_{\min} \geq 2t_{ec}+1$.

The design procedure of tec-error-correcting BCH code length n is described as:

1. Choice a primitive root α in a GF(2^m).
2. Select 2tec consecutive powers of α.
3. Obtain the minimal polynomials despite 2tec-consecutive powers of α having the same minimal polynomial for the roots in the same conjugacy class.
4. Obtain the generator polynomial g(x) by taking the LCM of the minimal polynomials for the 2tec consecutive powers of α.

It clearly says that this code has capable of correcting at all combination of t or less errors in a block n=2^m-1. This code has t-error-correcting BCH code and is constructed by approving their zeros, i.e., the roots of their generator polynomials:

A BCH code of dmin ≥ 2td + 1 is generator polynomial $\bar{g}(x)$ has 2td consecutive roots αb, αb+1, αb+2td-1.Therefore, a binary BCH (n,k,dmin) code has its generator polynomial expressed as

$$\bar{g}(x) = LCM\{\varphi_b(x),\ \varphi_{b+1}(x),\ldots,\ \varphi_{2+td-1}(x)\}, \tag{5}$$

Whose length n = LCM{nb, nb+1, . . . , nb+2td-1}, and dimension k = n - deg[$\bar{g}(x)$]. A binary BCH code has a designed minimum distance equal to 2td + 1. However, its true minimum distance sometimes larger.

A limit bound on the dmin of a BCH code, well declared as the BCH bound. This is not only to estimate the error-correcting capabilities of cyclic codes but also highlight the particular features of BCH codes. Note that the elements αb, αb+1,…,αb+2td-1 are roots of the generator polynomial $\bar{g}(x)$, and that every codeword $\bar{v}$ in the BCH code is associated with a polynomial $\bar{v}(x)$, which is a multiple of is declared as

$$\bar{v}(x) \in C \iff \bar{v}(\alpha^i)=0,\ b \leq i < b+2_{td} \tag{6}$$

BCH codes adopted over GF(q) with block length qm-1(q raise power m minus 1) are named primitive BCH codes and why this primitive block length is important is because it can help us factor is every easily.

For BCH code intuitively, a fixed length n, a larger t will force the information length k to be smaller (as a higher redundancy required to correcting much more errors). The deg (g(x)) = n-k, the designed distance d =2t+1. The designed distance is equal to the minimum distance. Ex : BCH(15,11), BCH(15,7), BCH(15,5), This BCH(15,11) code can specifically correct (dk-1)/2 = 7 random errors [3]-[6], [17].

The decoding algorithm for a tec -error correcting BCH code. The error polynomial now be expressed as

$$\mathrm{E}(x) = e_{i1}x_{i1}+e_{i2}x_{i2}+\ldots\ldots..+e_{ik}x_{ik} \tag{7}$$

Let e_{ik} is magnitude w.r. to kth error (for all binary codes be the e_{ik} =1). The unknowns are i_1, i_2, ……., i_v and e_1,e_2, ……., e_v are effectively direct the locations and magnitudes of errors respectively soon.

The decoders to accomplish the succeeding tasks:

• Compute the syndromes,7 by evaluating the received polynomial at the zeros of the code

$$S_i \equiv \bar{r}(\alpha^i),\ i = b,\ b+1,\ldots,\ b+2_{td}-1 \tag{8}$$

• Find the coefficients w.r. to error-locator polynomial σ(x).

• Find the inverse roots of σ(x), i.e., the locate errors, $\alpha_{j1},\ldots,\alpha_{jv}$.
• Find the errors $e_{j1},\ldots,e_{jv}$. (Not needed for binary codes)
• Correct the received word with the error locations and found the values.

To Relate the RS (15, 9) and the BCH (15, 5) codes was described in Figure 4 the word lengths of binary and non-binary codes. One of its merits grown in announcing GF(2^m) arithmetic is given as decoding actions can be executed.

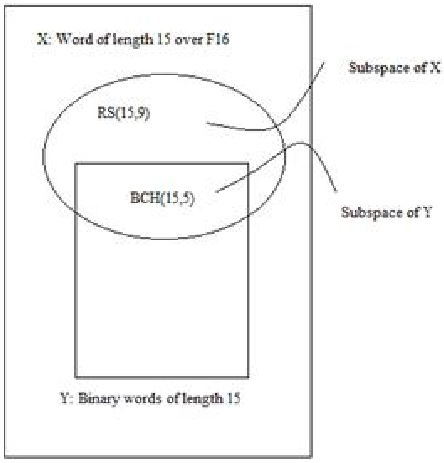

Figure 4: Relate the RS (15, 9) and the BCH (15, 5) codes

2.2 Non -Binary RS Codes

They are key subset of non-binary BCH codes. We will realize shortly that there is no point in forming binary Reed Solomon Codes. They will have no meaning. We will look at effective non-binary BCH codes and the applications are at many places including lot of storage devices using CDs, DVDs, barcode, they all use Reed Solomon Codes because of it is burst error correcting capability. Wireless channels and mobile communications also employee Reed Solomon Codes. So do satellite communication and deep space communications including we have this digital TV, DVB standards and ADSL, xDSL also use some form of Reed Solomon Codes. So, they are present everywhere. There is very strong class of codes.

The special subfamily according to q-ary BCH codes for which m=1 is the most key coding technique are popularly known as Reed-Solomon (RS) codes in honor of their discoverers, Irving Reed and Gus Solomon. RS codes have been extensively used for error control in digital communication modern days [3]-[6], [7]-[13].

Let us primitive component (α), generator polynomial g(X) and minimal polynomial $\theta_i(\mathrm{X})$. The tec-error-correcting RS code has with symbols from GF(q) has all of its roots are $\alpha^1,\alpha^2,\alpha^3....,\alpha^{2t}$ of $x^{q^m-1}-1$. Because α^1 is a component of GF(q), its $\theta_i(\mathrm{X})$ is be simply $X-\alpha^i$. Then, it follows from that

$$\begin{aligned} g(X) &= (X-\alpha)(X-\alpha^2)....(X-\alpha^{2t}) \\ &= g_0 + g_1\,X + \ .....+ g_{2t-1}\,X^{2t-1} \end{aligned} \quad (9)$$

Thus, the RS code have the features: (1) The code length is one less than the code size alphabet, and (2) The minimum distance is one greater than the parity-check symbols (known as MDS codes). RS codes are treated as the most important family of MDS codes.

Basic Properties of Reed–Solomon Codes:

1. The non-binary BCH codes are easily indicated as RS codes.
2. The RS code minimum distance is dmin =n-k+1.
3. The dmin ≤ n-k+1. RS (n, k) code is called MDS when the bound satisfied the equality.
4. The RS code weight distribution polynomial is known.

In RS codes, both the error locator (extension field) GF(qm) and symbol (sub-field) field GF(q) are the same at m =1, all minimal polynomials are linear.

Look at this case, n = qm-1 = q-1

The generator polynomial for a error correcting code will be simply as

$$\begin{aligned} g(x) &= LCM\left[f_1(x)\,f_2(x)....f_{2t}(x)\right] \\ &= (x-a)(x-a^2)....(x-a^{2t-1})(x-a^{2t}) \end{aligned} \quad (10)$$

The degree of this g(x) will always be 2t, thus RS code satisfies n-k =2t,code can be written as

$$g(x) = (x-a_i)(x-a_{i+1})....(x-a_{2t+i-1})(x-a_{2t+i}) \quad (11)$$

Table 2: Typical RS code parameters are as

M	q=2m	n=q-1	t	k	dm	r=k/n
2	4	3	1	1	3	0.3333
3	8	7	1	5	3	0.7143
			2	3	5	0.4286
			3	1	7	0.1429
4	16	15	1	13	3	0.8667
			2	11	5	0.7333
			3	9	7	0.6000
			4	7	9	0.4667
			5	5	11	0.3333
			6	3	13	0.2000
			7	1	15	0.0667
5	32	31	1	29	3	0.9355
			5	21	11	0.6774
			8	15	17	0.4839
8	256	255	5	245	11	0.9608
			15	225	31	0.8824
			50	155	101	0.6078

To Sifting RS codewords represented in the Figure.5

RS as MDS code:

Maximum distance separable code (MDS) code is the follower of RS code and its dmin is n-k+1. Let us for RS code the designed distance can be the d =2t+1.

The dmin is d* >=d=2t+1, but code has, 2t = n-k

Hence, d* >=d=2t+1 =n-k+1

Therefore d* =n-k+1 and the minimum distance d* =d, so the minimum distance and the designed distance are same [3]-[6], [16].

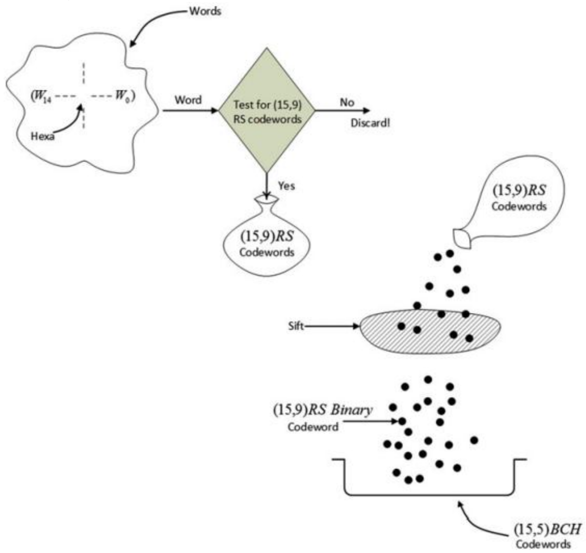

Figure 5: To Sifting RS codewords

The code words are as far as possible algebraically in the code space. For a given dmin, so as to have high code rate, and work with larger Galois Fields [3]-[6], [17].

The RS(255,223) over GF(255). Each has 255 code words, has data bytes =223 and parity bytes=32.

For this code, n =255, k =223 and n-k = 32

2t = 32 or t = 16.

Thus the decoder has capable to correct any 16 symbol random errors in the given code word, i.e., errors in up to 16 bytes in the specific code word can be corrected easily [18], [19].

3. PROPOSED MODEL

In frequency division multiplexing (FDM) the available frequency band is split up in to more sub-carriers (SC). To avoid Inter Carrier Interference (ICI), the SCs are separated, but this is not very efficient. By using orthogonal carriers, the SCs are allowed to overlap by 50 % without any crosstalk between the SCs, leading to a high spectral efficiency. This concept is known as orthogonal frequency division multiplexing (OFDM). By introducing a guard interval (GI), the orthogonality can be maintained even over dispersive channels. OFDM is an effective parallel data transmission scheme, which is robust against narrowband interferences, but sensitive to frequency offset and phase offset.

Figure 6 represents a simple OFDM transmission scheme. The scheme can be split up in three groups, where only the first part is relevant for this work. The first part covers symbol mapping and forward error correction coding, which is further second part is the actual OFDM part including modulation, where the data given in frequency domain into time domain using Inverse DFT. That part also includes the guard interval (GI) insertion at the transmitter side, GI removal and demodulation, using DFT at the receiver side. The third part is the RF–modulation/ demodulation and transmission over the communication channel. The BCH and RS codes are applied here to improve the much more performance [1]-[6].

It is clear out the performance situations improves from BCH and RS coding procedures with OFDM transceivers is invited in given block diagram Figure 6. The evaluated coded OFDM thru k-integer data with m-bit symbols are encoded by BCH/RS block which will generate codeword and communicate n-k additional message to decode at the receiver to detect the errors. One redundant symbol is needed to locate error for each and another redundant symbol is to find its correction. Here, in the process encode via RS/BCH encoder (code rate is ½, N=512) , mapping, modulate (QPSK/QAM) and OFDM (IFFT) thru each subcarrier will assigned one baseband symbol, CP (to cancel out the ISI), ZP (to add extra powers to IFFT). These CP/ZP are to boost the system to improve performance with help of reduce the demerits of data rate transmission. The AWGN channel helps to study and analyze the effect of the natural signal properties (L, L-1 signal from LoS and NLoS to multipath) [16], [17]. At the receiver side, removal of CP, ZP, and reverse the same at receiver section with removal of CP, ZP, OFDM demodulator (FFT), BCH/RS decoder, equalizers (FDE). The concept of error correcting codes BCH and RS codes used to associating their error performances to improve the communication reliability and growth the transmission rate. Consequently, the bit rate is better, and communication reliability is improved without extra redundancy [14]-[15].

In the transceivers both interleaver/ deinterleavers are also placed in the respective sections. L threshold to choose L paths was selected randomly for each transmission in Figure 7. It SNR can be accepted to consider the received signal as the original transmitted signal based on threshold. The threshold range 40% - 75% from the SNR of the LoS signal..

The final step in the simulation is to compute the BER to analyze and study the performance behavior of the coded communication with and without the existing multipath propagation.

The recovery signal y(n) is presented as

$$y(n) = h(n)*x(n)+w(n)$$

in this, h(n) is channel response, * be the convolution process and in frequency domain Y[k] be the received signal and it can expressed as

$$Y[K] = X[K]*X[K]+W[K]$$

The FDE is the most attractive choice in OFDM equalization in different fading scenarios.

Case i) zero forcing (ZF) equalizer: Z[k} is estimated signal suitably given as

$$Z[k] = \frac{Y[k]}{\hat{H}[k]} = \frac{H[k]X[k]}{\hat{H}[k]} + \frac{W[k]}{\hat{H}[k]} \tag{12}$$

So that, $Z[k] = X[k] + \frac{W[k]}{H[k]}$ when $\hat{H}[k] = H[k]$

Let, $\hat{Z}[k] = Z[k]H[k]$ then

$$\hat{Z}[k] = X[k]H[k] + W[k] \tag{13}$$

Case ii) MMSE equalizer: Z[k} is estimated signal suitably expressed like ZF equalizer.

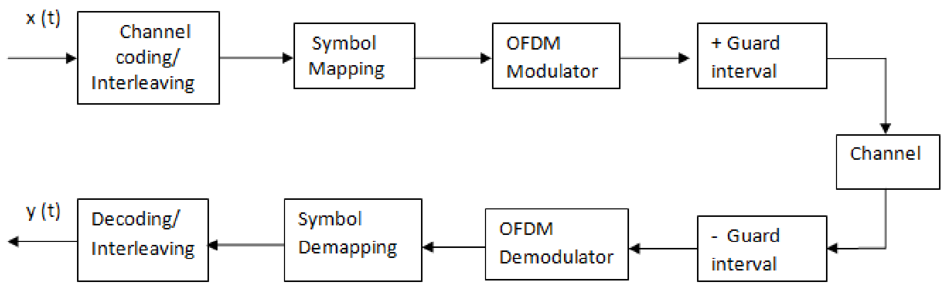

Figure 6: Typical OFDM Transceiver Architecture

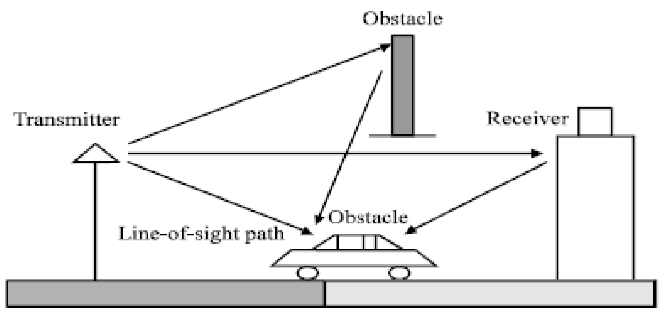

Figure 7: Typical path received from mobile antenna MIMO-coded-OFDM

4. SIMULATION RESULTS

BER Performance of BCH and RS Codes over AWGN channel: here, the binary modulations are first implemented next to that higher orders and trade off the BER thru higher orders.

$$P = Q\left(\sqrt{2R\frac{Eb}{No}}\right) \quad \text{for BPSK} \qquad (14)$$

$$P = \frac{1}{2}\exp\left[-\frac{REb}{2No}\right] \quad \text{for BFSK} \qquad (15)$$

$$BER_{M-PSK} = \frac{2}{\log_2 M} Q\left(\sqrt{\frac{2E_b \log_2 M}{N_0}} \sin\frac{\pi}{M}\right) \qquad (16)$$

$$BER_{M-QAM} = \frac{4}{\log_2 M}\left(1-\frac{1}{\sqrt{M}}\right)\sum_{i=1}^{\sqrt{M}/2} Q\left(\sqrt{\frac{3\log_2 M}{(M-1)}.\frac{E_b}{N_0}}\right) \qquad (17)$$

The following Figures for the BCH and RS with different carrier offsets (0 to 0.3). As the value of carrier offsets increases then the BER rate also increases. Comparatively RS have better performance than the BCH codes both for 16-PSK and 16-QAM.

Here, the adaptive digital modulations are QAM performs much better than QPSK techniques at the order of M=16 when we considering BER. The RS codes outperforms the BCH codes with carrier offsets and BCH codes gives better performance than the RS codes without carrier offsets at gradual higher SNRs for 16-QAM modulation.

The BCH code offers better improvement at 21dB with c-offset is zero (BER =0.0002). Meanwhile the RS codes have BER = 0.0012 at SNR = 21dB for 16-QAM modulation.

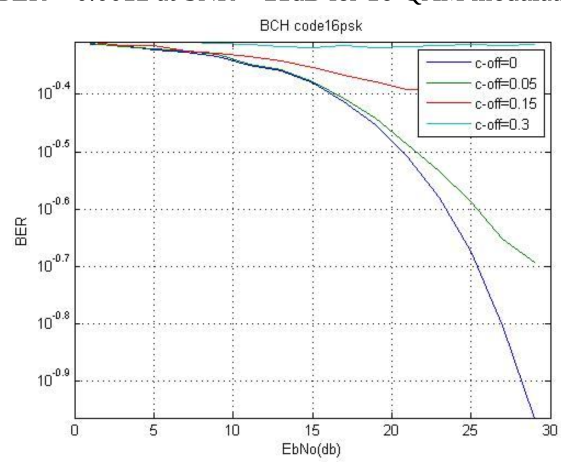

Figure 8: BER for BCH code with OFDM for 16 -PSK

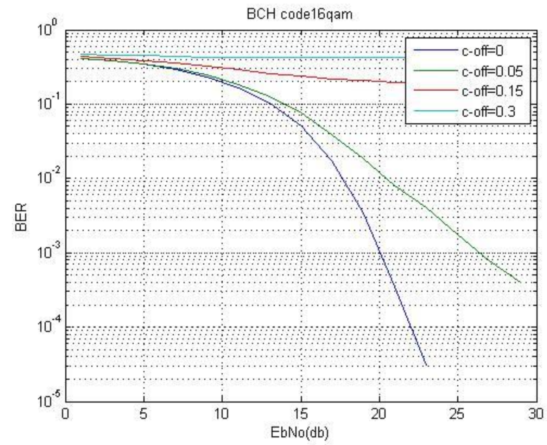

Figure 9: BER for BCH code with OFDM for 16 -QAM

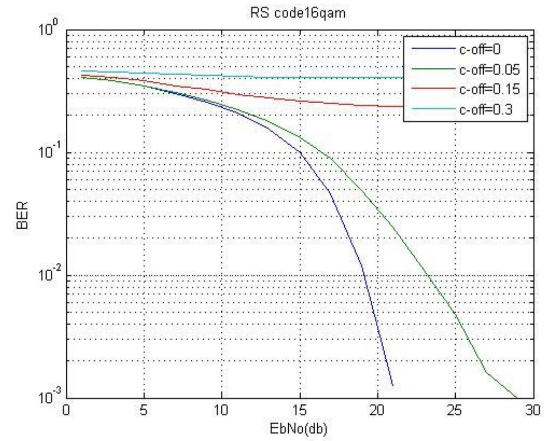

Figure 10: BER for RS code with OFDM for 16 -QAM

Here, BER performance analyzes with the modulation schemes and however the BER inverse with modulation order. Consider the QAM and QPSK with preferable orders and most of the authors recommended QAM. According to order the 16-QAM is more preferable than other higher modulations.

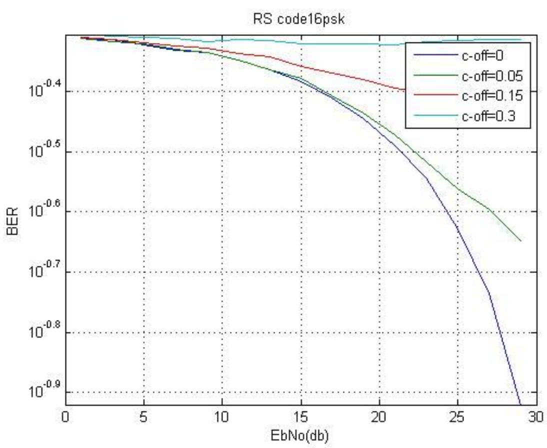

Figure 11: BER for RS code with OFDM for 16 –PSK

In the above Figure 8 to Figure 11 it shows the different SNR for different carrier offsets. As the carrier offset increases then the BER increases. This the curve for the BCH/RS code considering modulation 16-QAM compare with 16-PSK.

At lower SNRs RS code outperforms the BCH code for 16-QAM modulation.

The Table 3 discussed here the performance of BER Analysis for BCH and RS code with carrier offset parameters are as given better features according to their modulations.

Table 3: BER Analysis for BCH and RS code with carrier offset parameters are as

Type	SNR in dB	BER							
		Carrier offset with BCH code				Carrier offset with RS code			
		0	**0.05**	**0.15**	**0.3**	**0**	**0.05**	**0.15**	**0.3**
16-PSK	**5**	0.4731	0.4731	0.4786	0.5011	0.4640	0.4748	0.4834	0.4906
	9	0.4520	0.4528	0.4674	0.4881	0.4602	0.4613	0.4676	0.4899
	15	0.4159	0.4164	0.4404	0.4804	0.4126	0.4184	0.4405	0.4799
	21	0.3307	0.3627	0.4093	0.4786	0.3288	0.3376	0.4058	0.4801
16-QAM	**5**	0.1646	0.1659	0.1905	0.2525	0.1698	0.1737	0.1905	0.2221
	9	0.1202	0.1251	0.1584	0.2401	0.1318	0.1481	0.1584	0.2089
	15	0.0510	0.0735	0.1318	0.2243	0.1006	0.1096	0.1381	0.2041
	21	0.0002	0.0008	0.1231	0.1995	0.0013	0.0163	0.1286	0.1949

5. CONCLUSION

In this paper the BER analysis of OFDM system is carried out using various coding techniques with increased QAM/PSK modulation orders. The simulation results shows that the RS coded OFDM system is efficient for the power limited channels such as satellites. It achieves better performance even at low Eb/No values. The comparison among CRC, Hamming codes is represented using the obtained values. Though RS coded systems performs well, the complexity is traded off compared to BCH coded system. Hence, in the most of wireless communicating equipment RS codes are employed. This paper can be further extended using error correcting codes like LDPC and Turbo codes. These codes have approached Shannon theoretical bounds for the communication channels.

6. FUTURE SCOPE

This work can be extended towards turbo and LDPC coding implementations may give better qualitative BER among the other preferable codes. Also fuzzy logic developed codes used to give superior.

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