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Channel Estimation in High Speed Train Communication in Wireless 5G

Krishna sindhoora Chennupati, Khalim Amjad Meerja

Abstract: ***High speed train communication is a very demanding issue now a days for reliable communication by the end users. For better reliability previous works based on encoding structures and different channels but they are not concentrated channel errors, if we estimate the channels we get more FER compared to previous work. In wireless communications polar codes plays major role in warless fading environment. For efficient wireless communication system design, channel estimation is the fundamental step in fading channels. Information bits and frozen bits are required for both SN-polar codes. Based on the above two data sets (i.e. info-frozen) efficient SN-polar code implementation is possible. But in conventional channel estimation methods additional pilots are inserted in the given data. Where as in SN-polar codes pilots are selected from the information bits. Therefore conventional polar encoding structure is not suitable for pilot selection every time. We propose E-UEPS structures are used for efficient coding structure, the basic advantage of the proposed encoding structure automatically improves the FER.***

I. INTRODUCTION

With the increased future smart transportation systems, rapid mobility takes place with variable Doppler shifts with time based phenomena in wireless communication encounter peak data rate problems. So we need efficient encoding and decoding schemes to increase the peak data rate in high mobility environment. Therefore 5G is the suitable candidate to attain data rates up to 20 Gb/s for eM-BB. So efficient coding scheme is a challenging task in wireless 5G for high mobility scenario. error correcting performance with finite length systematic polarcodes are far better.

Polar codes are basically used for capacity improvements [1]. Several researchers and academinicians are working on this continuously since long back. The current 5Generation and 3GPP tradeoff, polar codes are used in uplink and down link as a channel coding in eM-BB type of services. Polar codes also used in Ultra low latency and massive machine type communications. Compared to advanced-codes such as Low-density-parity-check (LD-PC) and successive-cancellation-list (S-CL), the

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* Correspondence Author

Krishna sindhoora Chennupati*, M.Tech (CESP), Department of ECE VR Siddhartha Engineering College, Vijayawada(A.P),INDIA

Khalim Amjad Meerja , Professor in the Department of ECE Department of ECE, Professor, VR Siddhartha Engineering College, Vijayawada (A.P), INDIA

Based on the channel reliability followed by a each bit to be encoded the construction of the polar codes are possible. The efficiency of the channel can be observed by SNR and code length. Therefore a polar code is more suitable and design complexity is low with accurate error-correction over channelized parameters with aspects of multiple codes [2].

The main contributions of this article are summarized as:

In Section II we discuss some key aspects about polarcodes, how it is applicable for 5G encoding schemes, In III Section we discuss previous method in detail along with the short comes. In IV section we discuss our proposed method .Results and Conclusions are discussed in Section V.

II. BASIC CONCEPTS OF POLAR-CODES

In this section we discuss the basic definition of polar-codes, frozen set and decoding with the basic system over view of polar code for both uplink and down link.

A. Definition of polar codes

Let us consider length of the polar-code N, with dimension K and implement using the generator matrix $G_N = G_2^{\otimes n}$, where n= log(N), (.)⊗denotes the nth Kronecker power and

$$G_2 = \begin{bmatrix} 1 & 0 \\ 1 & 1 \end{bmatrix} \quad (1)$$

First the message vector is encode **m**=[$m_0, m_1, \ldots, m_{(K-1)}$] with specified length K in order to first a vector is formed **u** = [$u_0, u_1, \ldots, u_{(N-1)}$] therefore **m** and **u** are inter related and appear on one another with the indexset I ⊆{0, 1, 2, . . .,N −1}.In polar-coding back ground theory, generally 'free-indices' are generally referred **I** and the complement $\mathbf{I}^c$ as the set of 'frozen indices' is the compliment of **I** and is denoted as $\mathbf{I}^c$. Both the encoder and decoder knows the **I** [1,3].

The 'free-indices' set I is same as the polar code construction for the overall available methods. The corresponding map is possible b/w **v2x** ∈ $\{1,-1\}^N$,and the symbols **x** passed through the impulse-response **h**=[$h_0, h_1, \ldots, h_{\mu-1}$] ,.ie.channel is an AWGN with (N_o/2,0), therefore the o/p of the channel s for **k** no. of elements are

$$r_k = \sum_{i=0}^{\mu-1} h_i x_{k-1} + n_k \quad (2)$$

Where $n_k \sim N(0, \sigma^2)$ is a circularly symmetric Gaussian- rv with $\mu = 0$ and σ^2=1.The SNR ratio per-bit is represented as $E_b/N_o = \sum_i h_i^2/(2R\sigma^2)$, where R = K/N[4,7].

The basic system model which comprises the combination of uplink and down link is described below

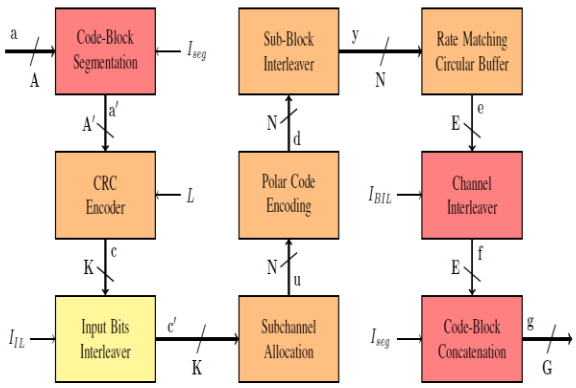

Fig 1: Basic system model combination of Uplink and down link

III. EXISTING MODEL OF HST WITH ENCODING STRUCTURE

A SYSTEM MODEL

OFDM is an MCM system generally used for Broad-Band-Applications (BBA) with this high peak data rates are possible.OFDM is a promising tool in multipath fading environmnent.Here bulk amount of data can be sub divided into number of parallel sub data streams and for very sub data streams one sub carrier is added along with the different modulation techniques mixed together in a muxed manner transmitted through a single channel with orthogonality condition. With huge benfits of OFDM in LTE and LTE-A, 5G mw is the modified structure of OFDM[10]. In our proposal, HST channel based polar OFDM system was considered with M subcarriers where both multipatheffect and Dopplereffect exist. polar coded OFDM system model is depicted in Fig.2

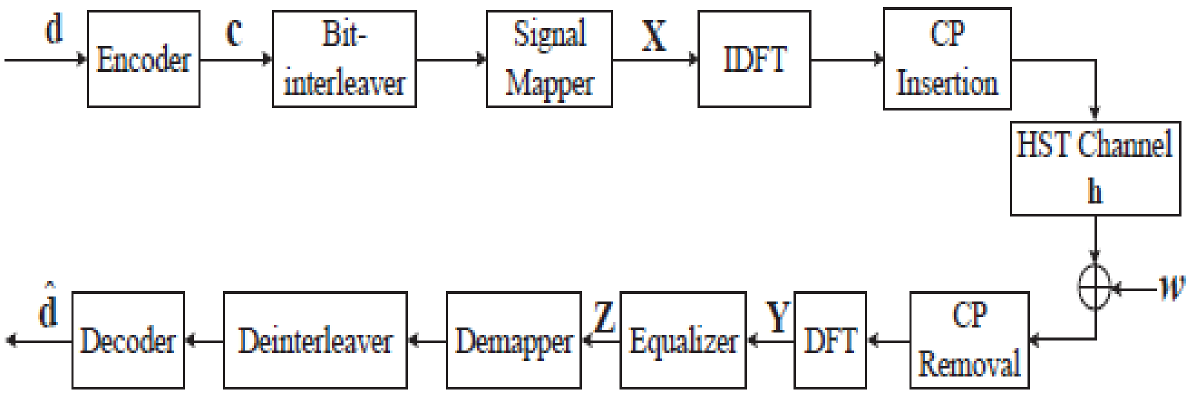

Fig 2: Existing model

IV. PROPOSED CHANNEL ESTIMATION WITH EPS AND UEPS

A SYSTEM MODEL

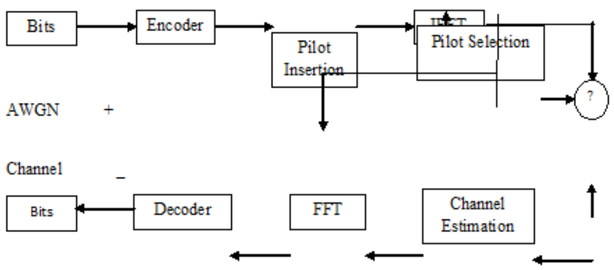

Fig 3: Proposed System model

Here proposed system model was shown in the Fig 3, and discussed in brief. The X denotes the binary date it should be encoded and passed through the specified channel $W\left(y/x\right)$. The diagonal matrix is denoted with $X = diag\left\{x_1^N\right\}$, where $\mathbf{x}_1^N$ represents the code words and the elements are taken from these code words. The received signal is then [2, 5]

$$y_1^N = h_1^N + z_1^n \qquad (3)$$

Where h_1^N=($h_1, h_2, \dots, h_N$) denotes the channelized response for every coded symbol. and z_1^N is the AW-GN noise -vector with mean=0 and variance $N_0/2$ for every coded symbol. Based on the channel parameters we conclude that there was no ISI in our proposal. Here the multipath fading channel h_1^N is a frequency selective Rayleighdistribution with a Dopplershift f_d. The zero-th order Bessel fun is the time correlation factor for jakes-spectrum model [8][11]:

$$R_{hh}(\mathrm{k}) = J_o\left(2\pi f_d KT\right) \qquad (4)$$

Where R_{hh} is known as auto-correlation-function for the rayleighfading channel.
The symbol duration is denoted with T. Therefore the remaining subsections, describes how the channel h_1^N can be estimated effectively with proper selection of the pilots.

B.UNEVEN PILOT SELECTION (UEPS)

The correlated-matrix is an invertible-matrix and denoted with G_{AA}.It is a lowertriangular matrix contains ones in the diagonal locations. By seeing the matrix G_{AA}we can observe that some of the columns are zeros except the diagonal location elements. Here in eqn(5) the hamming weights are indicated with w(·). So finally the set **S** over G_{AA} can be expressed as

$$S = \left\{ j : j \in \bar{A} \, and \, \omega\left(G_{\bar{A}_j}\right) = 1 \right\} \qquad (5)$$

where $G_{\bar{A},j}$ is the jth column of the submatrix $G_{\bar{A},}$. From the statement of proposition 1, $G_{\bar{A},j}$,:its a submatrix obtained from selection of rows from $\bar{A}$ of G_N. Therefore pilot selection decides the improvement of encoding scheme efficiency [2, 9, 11].

Proposition1: Uneven –PilotSelection (U-EPS): consider $P_f \subseteq S$ .selection of pilots from set A is based on required criteria. So that $C = A \cup P_f$! which gives $G_{\bar{C}C} = 0$

The pilot selection with improved encoding sceheme cab be illustrated by considering the example n=4 and R=0.5.We consider two sets one is information set $A = \{8,10,11,12,13,14,15,16\}$ and the frozenset $\bar{A}$= {1,2,3,4,5,6,7,9} The sub matrix $G_{\bar{A}\bar{A}}$ is provided below:

$$G_{\bar{A}\bar{A}} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Therefore from the above sub matrix$G_{\bar{A}\bar{A}}$, set-S evaluated as S = {4,6,7,9}. If $P_f \subseteq S$, and $G_{\bar{C}C}$= 0[1, 3, 6].

Given the pilot selection as in Proposition1, it is of interest to link it with the domination contiguous condition in [8].

C.EVEN PILOT SELECTION (EPS)

Before the introduction of the pilot selection in this section, a new set D is defined as

$$D = \left\{ 4k, 1 \le k \le N/4 \right\} \qquad (6)$$

Hence submatrix $G_{\bar{D}D}$ stated in the below proposition2.

Proposition 2: From equation (6), the submatrix $G_{\bar{D}D}$of G_N , $\forall \in 0 :$ $G_{\bar{D}D}$= 0.

Proof: The generatormatrix is $G_N = F^{\otimes n}$ where F = $\begin{pmatrix} 1 & 0 \\ 1 & 1 \end{pmatrix}$.The matrix G_N can be decomposed as:

$$G_N = F^{\otimes(n-2)} \otimes G_4 \qquad (7)$$

Observe the matrix G_4:

$$G_4 = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{bmatrix} \qquad (8)$$

From eqn (8) one non zero element in the position G_4 i.e the fourth element in the last coulmn. From eqn(6) the coulmns belongs to set D can be extracted from G_N.From eqn(7) G_N , $G_{:,D}$ is a matrix. Non zero elements of$G_{:,D}$ is apper in rows whrere as non zero elements of colums appear in fourth element G_4.Inotherwords, $G_{\bar{D}D}$= 0.

Based on the set **A** i.e information set. let $D_i = A \cap D$ and $D_f = \bar{A} \cap D$. The above following proposition supports the selection of second pilots improves the efficioent encoding schemes.

V. RESULTS AND DISCUSSIONS

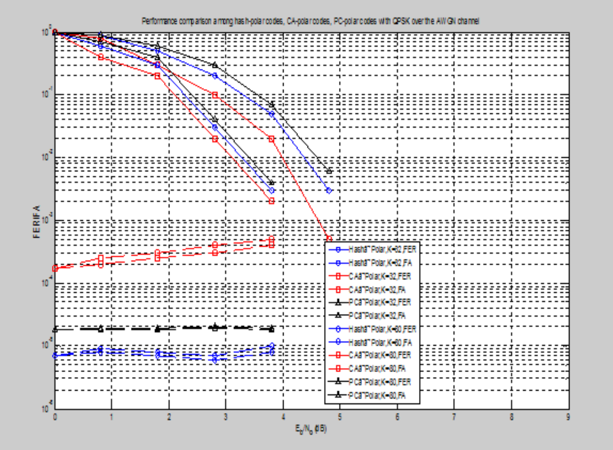

Fig4: Performance analysis of different polar codes with AWGN channel.

From Fig4 it provides the tradeoff between FA and FER with different polar coding schemes, both at K=32 and K=80.with code rate R=1/3 and L=8. It can also be seen that hashpolar codes have lower falsealarm rate and better-error-correcting performance than PC-polar codes

This results section indicates simulation for the selected pilots. Here LS and MMSE are compared under Rayleigh fading environment. The block length of the polar code is N= 256 by using BPSK modulation symbols are encodeded.For decoding process SC is applied. The test parameters are described as : the car freq is 900 MHz and the SE-rate is 256Kbps. TwoDoppler freq's f_d= 10 Hz and f_d= 50 Hz are used with respect to twovelocities v1=12 km/h & v2=60 km/h,

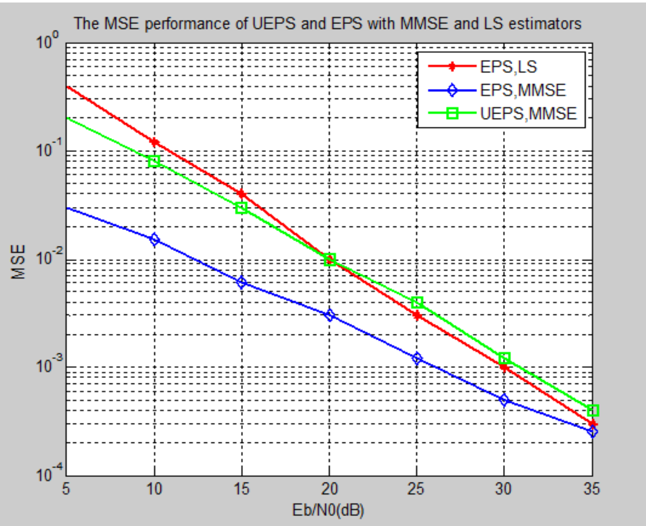

Fig5: MSE performance with different pilot selection schemes followed by different estimators under Rayleigh fading environment with polar code block lengths of N=64,256 with f_d=50 Hz.

From Fig. 5 MSE of the different estimators are compared i.e. LS and MMSE with rate code R=1/2. The performance of EPS-MMSE is better than EPS-LS estimator. Pilots distributions are different in UE-PS & E-PS. There was an error improvement in UE-PS-MMSE than E-PS-LS-estimator.

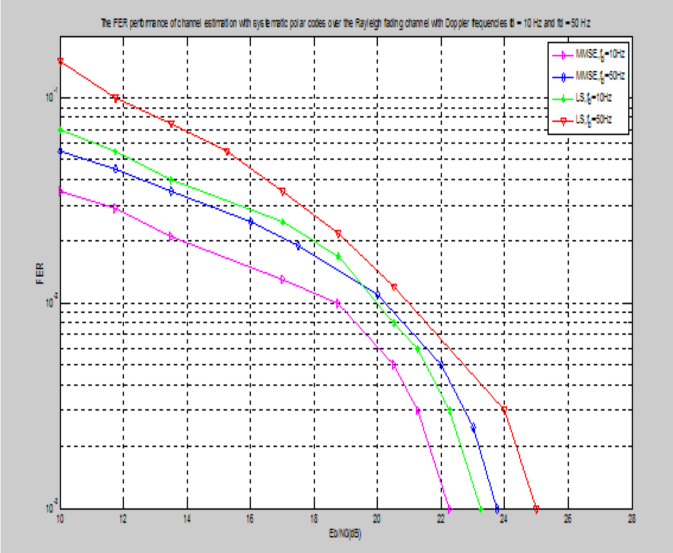

Fig 6: systematic polar code performance with channel estimation for FER under Rayleigh fading environment with f_d's=10Hz,50 Hz based on E-PS.polar code block length N=256 and rate code R=1/2.

Fig.6 provides the tradeoff between FER and E_b/N_o .MM-SE with f_d=10Hz is far better than LS with f_d=10Hz. But there was a shift in $f_{d=}$50Hz, performance degradeiation takes place compared to f_d=10Hz

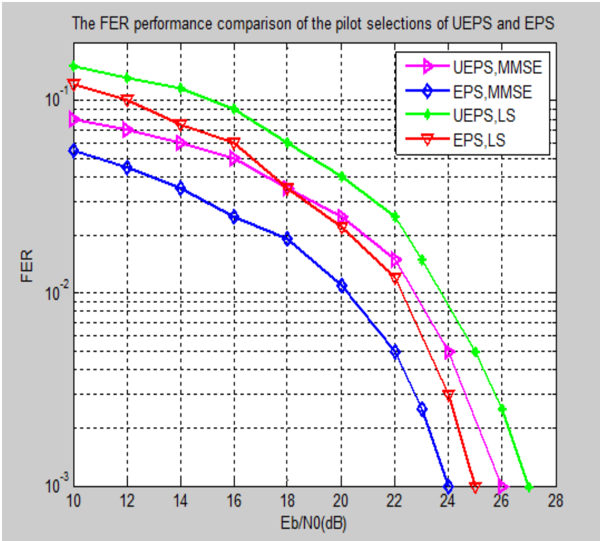

Fig 7: FER performance with different pilot selection schemes followed by different estimators under Rayleigh fading environment with polar code block lengths of N=256 with f_d=50 Hz followed by rate code R=1/2.

From the Fig7 when the Doppler shift is 50Hz. Better FER in E-PSMMSE is possible compared to UE-PS-MMSE.At a particular point FER of 10^{-3}, UE-PS MMSE requires 2 dB greater than E-PS-MMSE.Similar observations are possible for both UE-PS-LS and E-PS- LS.Depends on the selection of the pilots even selection performance is superior than uneven pilot selection positions.

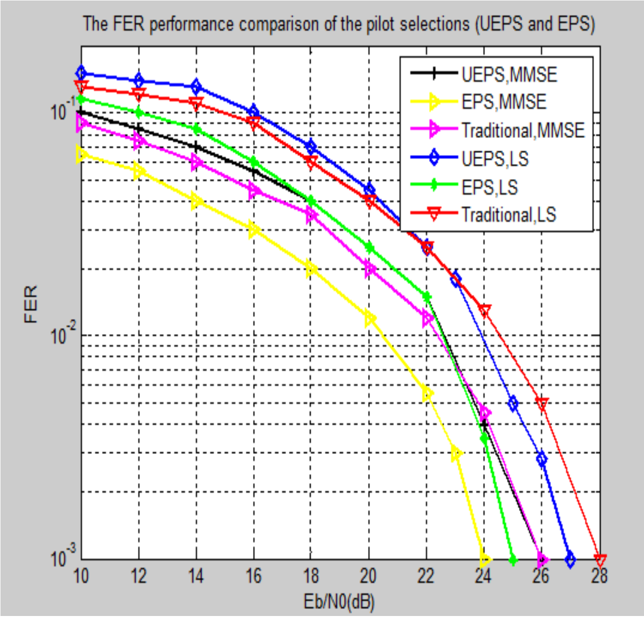

Fig 8: Comparison of considered pilot selection schemes (E-PS&UE-PS) with traditional pilot selection under Rayleighfading environment with f_d=50Hz with polar code length N=256 along with the code rate R=1/2.

Above graph shows the performance comparison between traditional and conventional pilot selection schemes. From Fig.8 the polar code block length is N=256 with rate code R=1/2 and fd=50Hz.Therefore, However,E-PS is more advantage than traditional pilot selection because all the inserted pilots acts as a channel.

VI. CONCLUSIONS

In this proposal, first we study the HST channel with different polar encoding and decoding techniques with different FER values. But offsets are lefted in previous schemes. In order to estimate the channel two efficient pilot selection schemes are introduced E-PS and UE-PS under fading environment. It will greatly reduce the insertion of additional pilots; both complexity and latency will be reduced just by use the coded symbols as pilots.howvever the decoding performance also greatly improved. Based on simulation results conventional pilot selection schemes are greatly improves the polar code performance than traditional pilot selection in wireless communications.

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