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Reduction of PAPR in OFDM Systems with Low Complexity using IS-LDPC Codes and QAM Modulation Technique

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Abstract: ***Low density parity check (LDPC) codes are one of the most powerful error correcting codes available today. A peculiar type of Low density parity check (LDPC) codes called invertible subset low density parity check (IS-LDPC) codes is proposed to reduce the peak-to-average power ratio for OFDM systems with low complexity. In these codes the underlying idea is each invertible subset can be independently inverted to generate other valid code words of the LDPC code. The development of IS-LDPC codes is by applying a modified progressive edge-growth algorithm (PEG). The simulation results displays that the IS-LDPC codes exhibit good error-correcting performance which is very close to that of the corresponding LDPC codes. The proposed IS-LDPC codes has much lower searching complexity when the codeword is transmitted by multiple OFDM symbols and could serve as an interesting PAPR reduction solution for multicarrier communication systems.***

Keywords: Orthogonal Frequency-Division Multiplexing (OFDM), Peak-to-Average Power Ratio (PAPR),Low Density Parity Check (LDPC) codes, Progressive Edge-Growth (PEG).

1. Introduction

Orthogonal frequency-division multiplexing (OFDM) is the mostly used multicarrier transmission technique in wireless communication standards, which presents high spectral efficiency, immune to the multipath path delay spread tolerance, low inter-symbol interference (ISI), immune towards frequency selective fading and high power efficiency. Due to these inherent advantages OFDM [2] is chosen as high data rate communication systems such as Digital Audio Broadcasting (DAB), Digital Video Broadcasting (DVB) and many more applications. However OFDM system suffers from serious problem of high PAPR. High PAPR complicates the implementation of the radio frequency front-end. To reduce PAPR, number of methods has been proposed in the literature [1]. Some of the reduction techniques are coding-based candidate generation schemes, companding transforms, partial transmit sequence (PTS) [3] and [4], and tone reservation.

Compared with all the techniques coding-based candidate generation scheme have attracted more attentions due to they have built-in error control capability simplicity of application. Therefore, we focus on the coding-based candidate generation schemes in this paper. Still, the defect of existing coding-based candidate generation schemes is high complexity of searching the candidate with the lowest PAPR. So they present limited PAPR performance, which will be elaborated in Section II.

In this paper, we first suggest a code structure that enables each OFDM symbol to be individually treated for PAPR reduction. By adopting these codes the searching complexity for the lowest PAPR candidate can be significantly reduced. Then a new type of LDPC codes called as invertible subset LDPC (IS-LDPC) codes has been introduced which are identical to the proposed code structure. The basic principle of these codes is they consists of number of disjoint invertible subsets and each subset can be individually inverted to generate candidates codewords that are valid codewords of the LDPC code, which can be constructed using a modified progressive edge-growth construction algorithm.

2. Preliminaries

2.1 Coding-Based Candidate Generation Schemes

We just memorize the PAPR reduction scheme proposed in [5] as an example of coding-based candidate generation schemes. In this scheme at the transmitter U binary labels inserted as a prefix drive a scrambler to generate a scrambled output of the information bits. Later, the encoded output is mapped onto OFDM subcarriers. The PAPR is reduced by choosing the proper labels at the receiver. The benefits of this are they do not suffer serious degradation of error-correcting performance and the side information i.e., label bits in [5], is fixed in codewords for transmission other than transmitted by an extra control channel. The scheme in [5] requires searching among 2^U number of candidates to reduce the PAPR, which means the searching complexity is 2^U.

2.2 Multiple-OFDM-Symbol Frames

In a practical OFDM system the codeword is to be transmitted through multiple OFDM symbols instead of single OFDM symbol. The well known example of such a practical system is IEEE 802.11a standard for Wireless Local Area Networks (WLAN) [6]. We call the multiple OFDM symbols, by which a single codeword is transmitted, as a multiple-OFDM-symbol frame in this paper. To reduce PAPR effectively U has to be much larger for a multiple-OFDM-symbol frame concurrently, the searching complexity becomes a harsh problem when we consider multiple-OFDM-symbol frame.

2.3 Proposed Code Structure with Low Searching Complexity

To decrease the searching complexity we recommend a code structure with low searching complexity. In coding-based candidate generation schemes, a new codeword is generated for a given codeword, by flipping a label bit. The new codeword alters from the original one only in the bits of symbol 'F' in Figure 1. For the scheme in [11], the Fig.1(a) suitable and the followings properties are observed: (1) the positions of the flipped coded 'F' bits depends on the information bits and other label bits; (2) the flipped coded bits are spread over multiple OFDM symbols.

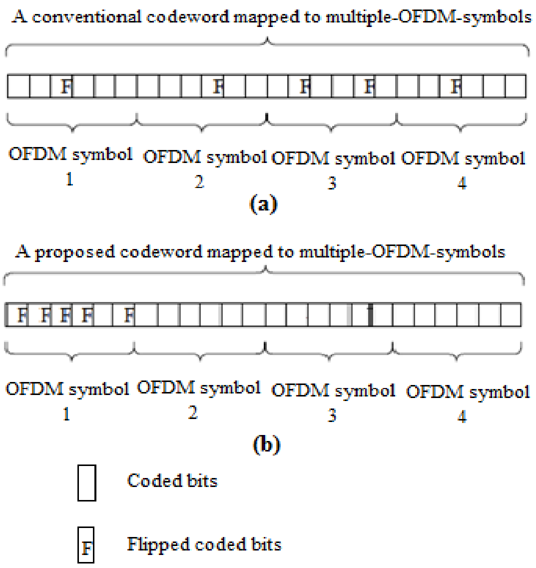

Figure 1: The proposed code structure with low searching complexity.

With this code structure, the PAPR of each OFDM symbol cannot be individually treated, so searching among the entire set of candidate codewords is necessary, i.e., 2^U searching complexity.

To shorten the above problem we propose a code structure that consists of low searching complexity. The proposed code structure has the following properties: (1) for any given label bit, the positions of the flipped coded bits do not depend on the information bits or other label bits; (2) there exists a appropriate position of coded bits to OFDM symbols, such that for each label bit, all flipped coded bits are assigned to the same OFDM symbol, as illustrated in the Fig. 1(b). With this structure and proper bit assignment, the candidate codeword generated by flipping any label bit differs from the original one in only one OFDM symbol. In this case, the PAPR of each OFDM symbol can be individually treated. In that event, instead of searching among the entire set of candidate codewords, only a subset of candidate codewords is required, whose size is much smaller than 2^U.

If we consider the case that the frame consists of K OFDM symbols and each OFDM symbol is associated with U/K label bits, the searching complexity for each OFDM symbol is $2^{U/K}$ and total searching complexity for a codeword is reduced from 2^U to $K2^{U/K}$.

To construct a code having good error-correcting performance and the proposed code structure, LDPC codes [7] are the good choice. This behavior of LDPC codes lead to the proposed IS-LDPC codes in the following section.

3. Proposed IS-LDPC codes

3.1 Definition of IS-LDPC code

Definition 1:

Let vector **A** = $[a_1, a_2, \dots, a_N]$ denote a codeword of binary linear block code **A,** and subset **S**= $\{i_1, i_2, \dots, i_L\}$ denote a subset of indexes of the coded bits, i.e., $\{i_1, i_2, \dots, i_L\} \subseteq \{1,2,\dots,N\}$. Subset ***S*** is an invertible subset if, for any valid codeword **A** of **A,** codeword $\tilde{A} = [\tilde{a_1}, \tilde{a_2}, \dots, \tilde{a_N}]$ is a valid codeword of **A** , where

$$\tilde{a}_i = \begin{cases} \bar{a}_i, & i \in S \\ a_i, & \text{Otherwise.} \end{cases}$$

Let us look at an example code as shown in Figure 2. This contains 4 coded bits and 8 codewords. The left most block contains all the valid codewords of the represented block code.

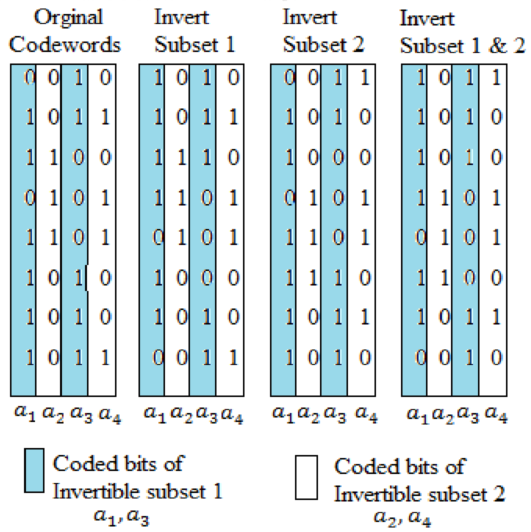

Figure 2: An example block code with two disjoint invertible subsets.

Therefore, for any given codeword the other valid codewords can be formed only by inverting subset 1 or subset 2 or by inverting both the subsets. The conversations in this paper involve irregular LDPC codes with variable node and check node degree distributions as follows,

$\lambda(x) = \sum_{i=2}^{d_{v_{max}}} \lambda_i x^{i-1}$, and

$\rho(x) = \sum_{i=2}^{d_{c_{max}}} \rho_i x^{i-1}$

Where, $d_{v_{max}}$ and $d_{c_{max}}$ are the maximum variable and check node degree of the code, correspondingly. λ_i and ρ_i represent the fraction of edges coming out from degree i variable and check nodes, correspondingly.

Definition 2

An invertible subset LDPC (IS-LDPC) code of inversion freedom U is an LDPC code with U invertible subset, and there is no intersection among different invertible subsets. It is concluded that, all the multiple invertible disjoint subsets of the IS-LDPC code can be inverted independently. The IS-LDPC codes in practical communication systems needs to satisfy the following two requirements:

1) The inversion freedom U should be greater than the number of OFDM symbols K in a frame, because greater the inversion freedom lower the PAPR.
2) The number of coded bits and the indexes of coded bits for each invertible subset can be specified by the systems.

3.2 Properties of IS-LDPC Parity-Check Matrices

Let S_{IS} denote an invertible subset, and vector $\boldsymbol{A}_{IS}$ denote the corresponding coded bits. Let S_{OT} denote the subset of the coded bits that do not belong to S_{IS}, and vector $\boldsymbol{A}_{OT}$ denote the corresponding coded bits. Note that, other invertible subsets could be included in S_{OT}. The coded bits are rearranged such that the codeword $\boldsymbol{A} = [\boldsymbol{A}_{IS}, \boldsymbol{A}_{OT}]$. Similarly, the variable-node set V is partitioned into two subsets V_{IS} and V_{OT}, where V_{IS} and V_{OT} compares to S_{IS} and S_{OT}, respectively. As a Tanner graph defines a parity-check matrix, the parity-check matrix **H** also consists of two sub matrices, i.e., $\boldsymbol{H} = [\boldsymbol{H}_{IS}, \boldsymbol{H}_{OT}]$, where $\boldsymbol{H}_{IS}$ and $\boldsymbol{H}_{OT}$ are sub matrices of $\boldsymbol{H}$, and the columns of $\boldsymbol{H}_{IS}$ and $\boldsymbol{H}_{OT}$ correspond to the variable nodes in subset V_{IS} and V_{OT}, respectively.

Theorem 1: A necessary and sufficient condition for S_{IS} to be an invertible subset of the LDPC code is that, each row of $\boldsymbol{H}_{IS}$ has even Hamming weight, i.e., $\boldsymbol{H}_{IS}[1,1,\ldots,1]^T = 0$ over GF(2).

Examining the theorem in terms of Tanner graph, the following remarks obtained.

Remarks:

1) A necessary and sufficient condition for S_{IS} to be an invertible subset of the LDPC code is that, for any check node, the total number of edges connecting the check node to all variable nodes in V_{IS} is even.
2) It is inferred from Remark 1 that if S_{IS} is an invertible subset, the total number of edges emerging from V_{IS} is even.

4. Construction of IS-LDPC codes

It is well known that to construct a LDPC code with good error correcting performance, PEG algorithm [8] is the best solution, This algorithm grows the graph in an edge-by-edge manner. In this section, the IS-LDPC codes might be constructed by using a modified PEG algorithm called as IS-PEG algorithm which is based on Theorem 1 and the Remarks in Section III. The basic concept of the IS-PEG algorithm is that:

1) The earlier edges grown for V_{IS} (the variable node set of the invertible subset) are grown following the same rule as that of the PEG algorithm.
2) The later edges grown for v_{IS} are forced to connect to the check nodes that are connected to v_{IS} odd times.

Algorithm 1: IS-PEG algorithm

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for j = 1 to N **do**
for k = 1 to d_{v_j}, where d_{v_j} represents the degree of variable node v_j , **do**
if k = 1 **then**
Update O, P and Q.
if $v_j \in V_{IS}$ and $P < Q$ **then**
$\mathcal{E}^1_{v_j} \leftarrow$ edge (v_j, c), where c is a check node such that it has the lowest check-node degree under the current graph setting $\mathcal{E} = \mathcal{E}_{v_1}, \cup \ldots \cup, \mathcal{E}_{v_{j-1}}$,
else
$\mathcal{E}^1_{v_j} \leftarrow$ edge (v_j, c), where c is a check node from O such that it has the lowest check-node degree under the current graph setting $\mathcal{E} = \mathcal{E}_{v_1}, \cup \ldots \cup, \mathcal{E}_{v_{j-1}}$,
end if, where $\mathcal{E}_{v_i}$ contains all edges grown for v_i, i.e., $\mathcal{E}_{v_i} = \mathcal{E}^1_{v_i} \cup \mathcal{E}^1_{v_i} \cup \ldots$, and $\mathcal{E}^m_{v_i}$ is the mth edge grown for v_i .
else
Update O, P and Q.
Expand a tree sub graph from variable node v_j up to depth l under the current graph setting $\mathcal{E} = \mathcal{E}_{v_1}, \cup \ldots \cup, \mathcal{E}_{v_j}$, such that the cardinality of $\mathcal{N}^l_{v_j}$ stops increasing but is less than M, or $\bar{\mathcal{N}}^l_{v_j} \neq \emptyset$ but $\bar{\mathcal{N}}^{l+1}_{v_j} = \emptyset$. Then, the set of check-node candidates
$\mathcal{N}$ is
if $v_j \in V_{IS}$ and $P < Q$ **then**
$\mathcal{N} = \bar{\mathcal{N}}^l_{v_j}$,
else
$\mathcal{N} = \bar{\mathcal{N}}^l_{v_j} \cap O$
end if
$\mathcal{E}^k_{v_j} \leftarrow$ edge (v_j, c), where c is a check node in $\mathcal{N}$, which has the lowest check-node degree.
end if
end for
end for

The equation gives the conclusion of above algorithm,

$$\mathcal{N} = \begin{cases} \bar{\mathcal{N}}^l_{v_j}, & P < Q \\ \bar{\mathcal{N}}^l_{v_j} \cap O, & otherwise \end{cases}$$

Where, $\bar{\mathcal{N}}^l_{v_j}$ is the complement of the set of check nodes v_j reached by the tree expansion from variable node up to depth l.

When running the IS-PEG algorithm, one situation may happen: there is no check node in the intersection of the two sets, i.e., $\bar{\mathcal{N}}_{v_j}^{l} \cap O = \emptyset$. In this case, check nodes are selected in $\bar{\mathcal{N}}_{v_j}^{l-1} \cap O$ instead.

5. PAPR Reduction with Low Complexity

The transmitter for transmitting the information bits of the OFDM system along with an IS-LDPC encoder is exhibited in the Figure 3 as

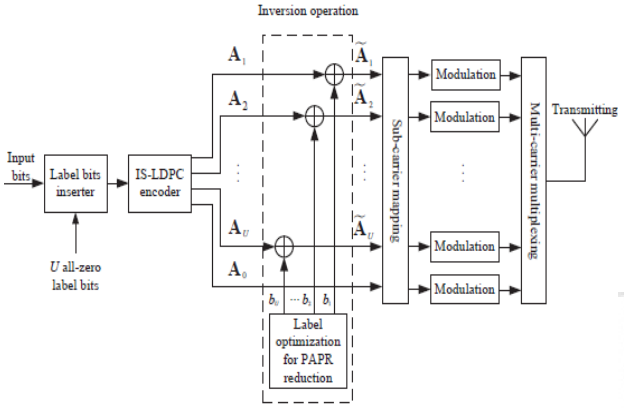

Figure 3: Transmitter of OFDM system.

After the IS-LDPC encoding, the coded bits are reordered and grouped based on the U invertible subsets, such that **A**=$[\boldsymbol{A}_0, \boldsymbol{A}_1, \dots, \boldsymbol{A}_U]$, where sub-vector $\boldsymbol{A}_u (1 \le u \le U)$ produces the coded bits of the *u*th invertible subset S_u , and sub-vector $\boldsymbol{A}_0$ represents the remaining coded bits that do not belong to any of the invertible subsets.

Let $\tilde{\boldsymbol{A}}_u$ denote the sub-vector after the inversion operation, for u = 1, 2, . . . ,*U*, and the codeword after the inversion operation is denoted as $\tilde{\boldsymbol{A}} = [\boldsymbol{A}_0, \tilde{\boldsymbol{A}}_1, \dots, \tilde{\boldsymbol{A}}_U]$. For the binary IS-LDPC code, the inversion operation could be realized by XOR operation as,

$$\tilde{\boldsymbol{A}}_u = \boldsymbol{A}_u \oplus \underbrace{[b_1, \dots, b_u]}_{L_u}, \text{ for } u = 1,2,\dots,U$$

Where L_u is length of *u*th invertible subset, and label $b_u \in \{0,1\}$ summarize, whether the subset u is inverted or not i.e., if b_u =1 then $\boldsymbol{A}_u$ is inverted and if $b_u = 0$ $\boldsymbol{A}_u$ is not inverted. Afterwards the coding procedure the achieved bits are mapped to sub-carriers of the OFDM which are modulated into phase shift keying (PSK) or quadrature amplitude modulated (QAM) symbols.

The label optimization module shown in Figure 3 generates a appropriate vector $[b_1, \dots, b_U]$ so that PAPR of the transmitted signal gets decreased. The figure characterize a method how to transmit the label bits i.e., *U* zero label bits are attached to the information bits before encoding. The IS-LDPC encoder employs systematic encoding after that each invertible subset attached with exactly one label bit, some information bits and parity bits. Supposing that a subset is inverted, the label bit and the information bits both get flipped.

After multicarrier demultiplexing, demodulation and subcarrier demapping, the transmitted codeword $\tilde{\boldsymbol{A}}$ is reclaimed by the decoder and the original codeword can be extracted as

$$a_i = \begin{cases} \tilde{a}_i \oplus b_i, \\ \tilde{a}_i, \end{cases}$$

if $i \in S_u$ and u=1,2,…,U,
Otherwise.
Where $\tilde{a}_i$ is the *ith* bit of $\tilde{\boldsymbol{A}}$.

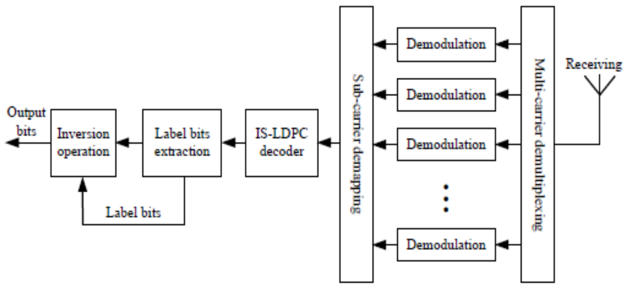

Figure 4: Receiver of OFDM system.

The code rate R_E (number of information bits over length of codeword) for the IS-LDPC code is (*RN − U*)/*N*, where *R* is the nominal code rate. If the above rate loss is not suitable then we can use the following conditions:(1) let the number of the information bits and label bits be RN and U, respectively; (2) construct an IS-LDPC code of inversion freedom *U*, with code length *N*+*U* and nominal code rate (*RN*+*U*)/(*N*+*U*); (3) encode the information bits and all-zero label bits as Figure 3; (4) puncture *U* bits in the codeword. After this operation the code rate and codeword length remains same as R and N.

6. Simulation Results

The error correcting performance and the PAPR performance of the IS-LDPC codes has been described in this section by the help of computer simulation results. The code rate is taken as either R=1/2 or R=3/4 but the degree of distribution is same for both IS-LDPC and LDPC codes i.e., $d_{v_{max}}$=15. The proposed IS-LDPC code is binary so limitations on modulation cannot be applicable, so we can employ either QPSK or 16-QAM modulation [9] at the OFDM transmitter in this paper we are applying both the modulation techniques separately for calculating the performance of PAPR. The receiver employs standard log-likelihood ratio belief propagation (LLRBP) decoder with a maximum of 80 decoding iterations.

In Figure 5. subset inversion is not applied because the actual error correcting capability of IS-LDPC codes can be determined before the inversion and it is compared with LDPC codes which are the well known good error correcting codes especially for short block length LDPC codes. From Figure 5 the error correcting performance of IS-LDPC is nearly equal to the corresponding LDPC codes for U<=32, R=1/2 and N=1024, but some degradation is observed when U=64 , R=1/2 and N=1024, Due to IS-LDPC codes cannot tolerate larger codeword length and higher inversion freedom without certain performance degradation.

Figure 6 and Figure 7 are focused on the BER and FER performances of the IS-LDPC codes when subset inversion is applied.

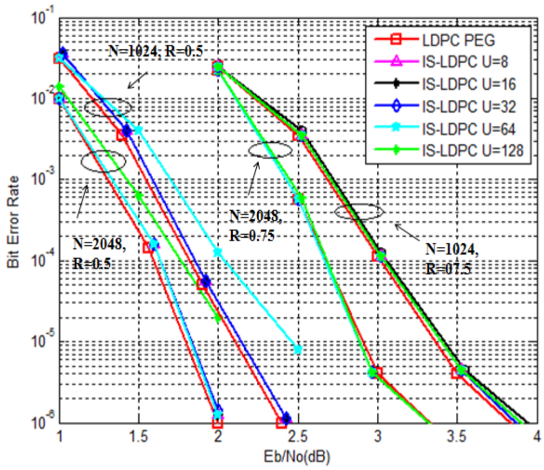

Figure 5: BER performance of the IS-LDPC codes over AWGN channel when no subset inversion is applied, with U = 8, 16, 32, 64 for N = 1024 and U = 64, 128 for N = 2048.

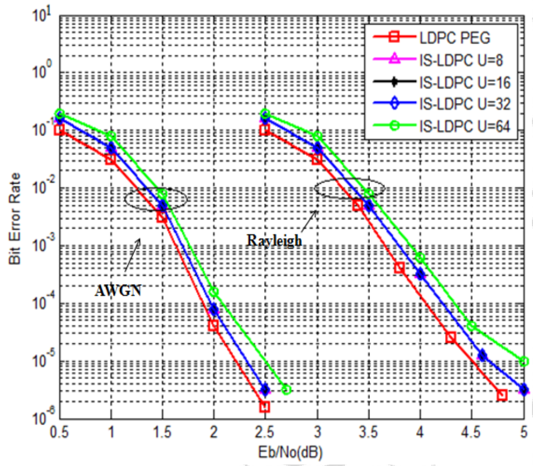

Figure 6: BER performance of the punctured IS-LDPC codes, with effective code rate R = 1/2 and N = 1024, over AWGN and uncorrelated Rayleigh channel. The subset inversion is applied.

The comparisons of IS-LDPC and LDPC codes with the same code rate, puncturing have to be applied to the IS-LDPC codes. In Figure 6 BER performance of IS-LDPC codes under AWGN and Rayleigh fading channel is observed. There exists a little performance gap, Due to failure of decoding label bits and wrong inversion of their information bits at the receiver. Figure 7 shows FER performance under AWGN and Raleigh fading channels, which is more preferable, compared to BER. It is observed that there is no significant FER performance loss for IS-LDPC codes when $U \leq 32$, over AWGN channel. The FER performance loss is slightly increased when the uncorrelated Rayleigh fading channel is applied.

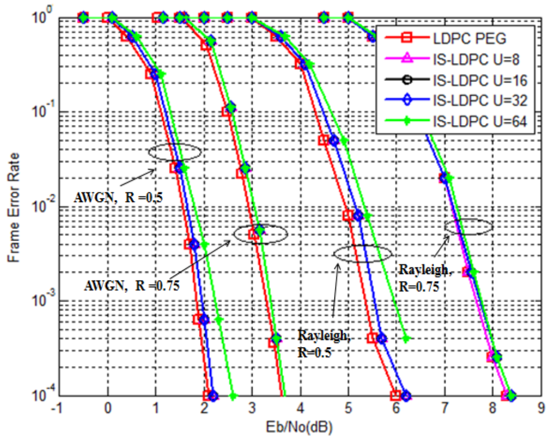

Figure 7: FER performance of the punctured IS-LDPC codes, with N =1024, over AWGN and uncorrelated Rayleigh channel when subset inversion is applied.

Figure 8 and Figure 9 illustrates the PAPR performance of OFDM system using QPSK and 16-QAM modulation schemes respectively. The OFDM system in the simulation employs 128 subcarriers (N_c = 128) and the codeword length N=1024, K=4. Punctured IS-LDPC codes are employed with R_E= 1/2.

Here, the performance of IS-LDPC is compared with PTS scheme. It is clear from the Figure 8 that the performance is almost same when compared to PTS, But PAPR reduced by increasing the number of candidates.

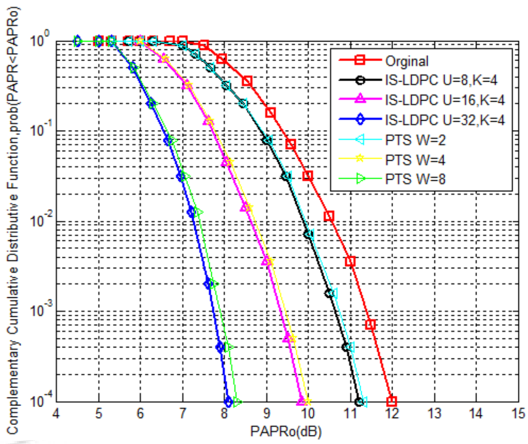

Figure 8: PAPR reduction of OFDM systems with IS-LDPC codes for QPSK modulation

This scheme offers a reduction of 0.9dB, 2.1dB and 3.98dB at CCDF=10^{-4}, When U=8, 16, 32 respectively. Actually, inverting a bit means the inverting of the in-phase or quadrature component of corresponding QPSK symbol, so the coded bits of all invertible subsets are mapped onto sign bits of symbols. Due to this similarity, PAPR performance of the PTS scheme is almost equal to IS-LDPC scheme, when U/K (the number of invertible subsets per OFDM symbol) equals to W (the number of PTS partitions).

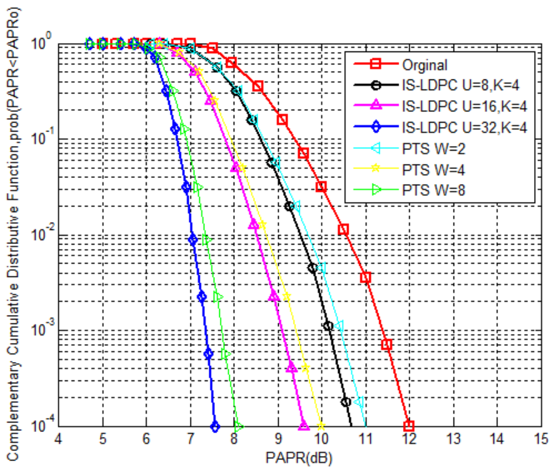

Figure 9: PAPR reduction of OFDM systems with IS-LDPC codes for 16-QAM modulation

Fig.9. shows the performance of IS-LDPC codes in PAPR reduction using 16-QAM modulation. Compared to QPSK modulation 16-QAM modulation scheme shows a better PAPR reduction performance, Due to the advantage of transmitting more bits per position as there are multiple points of transfer. This scheme offers a reduction of 1.3dB, 2.4dB and 4.5dB at CCDF=10^{-4}, When U=8, 16, 32 respectively. Compared to PTS scheme also the performance change is obtained as 0.2db, 0.25dB and 0.45db at CCDF=10^{-4} for U=8, 16, 32 respectively.

7. Conclusion

In this paper, a new novel type of LDPC code (IS-LDPC code) for PAPR reduction in OFDM systems is introduced. The main advantage of this coding scheme is compared with the existing schemes, the proposed scheme reduces the searching complexity from 2^U to $K2^{U/K}$, where 2^U is the number of candidates for each codeword and K is the number of OFDM symbols. The IS-LDPC codes exhibit good error performance, which is very close to that of the LDPC codes, for a wide range of U. The proposed PAPR reduction scheme demonstrate almost same PAPR performance as the PTS scheme, when U/K
(the number of invertible subsets per OFDM symbol) equals to W (the number of PTS partitions) when QPSK modulation is used but a better performance can be obtained by using 16-QAM modulation technique.

Considering all the above benifits the proposed IS-LDPC coding scheme is an attractive PAPR reduction scheme for multi carrier communication systems.

References

[1] T. Jiang and Y. Wu, "An overview: peak-to-average power ratio reduction techniques for OFDM signals," *IEEE Trans. Broadcast.*, vol. 54, no. 2, pp. 257–268, June 2008.
[2] K.Muralibabu and S.Padmanabhan, "PAPR Reduction using combined LDPC and DCT with Companding Transform in OFDM System," International Journal of Engineering Research and Development, Volume 3, Issue 12 ,September 2012.
[3] S. H. Muller and J. B. Huber, "OFDM with reduced peak-to-average power ratio by optimum combination of partial transmit sequences," *IEEEElectron. Letter*, vol. 33, no. 5, pp. 36–69, Feb. 1997.
[4] L. Li and D. Qu, "Joint decoding of LDPC code and phase factors for OFDM systems with PTS PAPR reduction," *IEEE Trans. Veh. Technol.*, vol. 62, no. 1, pp. 444–448, Jan. 2013.
[5] H. Breiling, S. H. Muller-Weinfurtner, and J. B. Huber, "SLM peakpower reduction without explicit side information," *IEEE Commun.Lett.*, vol. 5, no. 6, pp. 239–241, June 2001.
[6] IEEE Std 802.11a/D7.0 1999, Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: High Speed Physical Layer in the 5GHz Band.
[7] Daniel J. Costello, Jr. "An Introduction to Low-Density Parity Check Codes," Department of Electrical Engineering University of Notre Dame August 10, 2009.
[8] X. Y. Hu, E. Eleftheriou, and D. M. Arnold, "Regular and irregular progressive edge-growth Tanner graphs," *IEEE Trans. Inf. Theory*, vol. 51, no. 1, pp. 386–398, Jan. 2005.

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