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A Novel of Low Complexity Detection in OFDM System by Combining SLM Technique and Clipping and Scaling Method

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Abstract*—In order to increase the bandwidth efficiency and receiver robustness the wireless communication standards such as DVB-T2 or DVB-NGH are used. In order to fully exploit the multiple-input multiple-output (MIMO) channel capacity, the diversity and spatial multiplexing are combined. However, to achieve large capacity of Full-rate full diversity (FRFD) space-time codes, most of them present high complexity for soft detection. For that a low complexity soft detection algorithm is proposed for the reception of FRFD space-frequency block codes in BICM (Bit Interleaved Coded Modulation) orthogonal frequency division multiplexing (OFDM) systems. The low density parity check based SFBC MIMO transmission and reception scheme based on DVB-T2 is done here. The model is implemented using MATLAB. The proposed detector maintains a reduced and fixed complexity. Finally a combination of selective mapping algorithm and clipping and scaling is presented for the modification of OFDM system which results in low complexity with reduced PAPR noise and interference.

Index Terms—: **Space frequency block coding (SFBC), MIMO systems, orthogonal frequency division multiplexing (OFDM), peak-to-average-power ratio (PAPR), selected mapping (SLM).**

I. INTRODUCTION

Orthogonal frequency-division multiplexing (OFDM) is a well-known technique for transmission of high rate data over broadband frequency-selective channels.ORTHOGONAL frequency division multiplexing (OFDM) has many advantages such as robustness in frequency-selective fading channels, high bandwidth efficiency, efficient implementation, and so on. Hence, OFDM has made its way into many applications in both wire line and wireless environments. Some of well-known examples include digital audio broadcasting (DAB), digital video broadcasting-terrestrial (DVB-T), IEEE 802.11a, and IEEE 802.16. A major drawback of OFDM at the transmitter is the high peak-to-average power ratio (PAPR) of the transmitted signal. These large peaks require linear and consequently inefficient power amplifiers. To avoid operating the power amplifiers with extremely large back-offs, we must allow occasional saturation of the power amplifiers, resulting in in-band distortion and out-of-band radiation. There are many solutions to reduce the PAPR of an OFDM Signal. The first is distortion technique, such as clipping, companding and so on. This technique is simple, but it is inevitable to cause some performance degradation. The second is coding technique. It is an efficient method to reduce the PAPR for a small number of subcarriers, but it is inefficient transmission rate significantly for a large number of subcarriers. The third kind is probabilistic technique or the redundancy technique which is including selective mapping (SLM) and the Partial transmit sequence. The first is distortion technique, such as clipping, companding and so on. This technique is simple, but it is inevitable to cause some performance degradation. The second is coding technique. It is an efficient method to reduce the PAPR for a small number of subcarriers, but it is inefficient transmission rate significantly for a large number of subcarriers. The third kind is probabilistic technique or the redundancy technique which is including selective mapping (SLM) and the Partial transmit sequence.

II. EXISTING SYSTEM

The main aim of the existing system is to detect the low complexity of full rate SFBC in BICM-OFDM systems and its assessment in an LDPC-based BICM scenario. The basic structure of the LDPC-coded BICM-OFDM system is depicted in Fig. 1. As can be seen, the bit stream is coded, interleaved and mapped onto a complex constellation. Next, a vector of Q symbols s is coded into space and frequency forming the code word X, which is transformed into the time domain by an inverse fast Fourier transform (IFFT) block and transmitted after the addition of a cyclic prefix. At the receiver side, the prefix is removed, a fast Fourier transform (FFT) is carried out and the resulting signal Y of dimensions $N \times T$ can be represented mathematically as $Y = HX + Z$,

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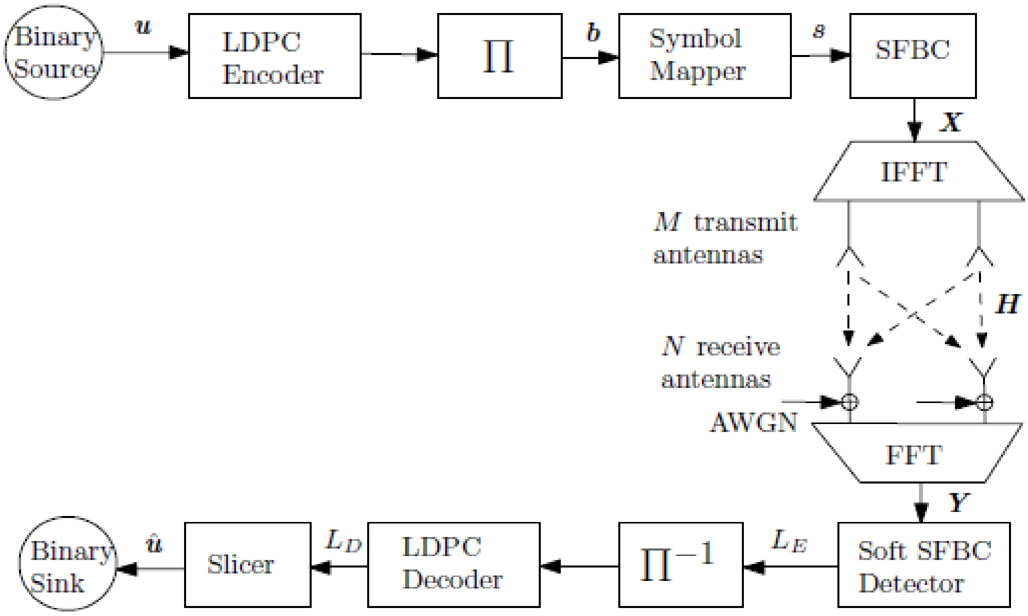

Fig:- 1 LDPC-coded BICM-OFDM system

TRANSMITTER SECTION

The transmitter section consists of low density parity encoder (LDPC), Interleaver or filter, symbol mapper, space frequency block coding (SFBC), IFFT. The combination of LDPC encoder. Interleaver and symbol mapper performs the Bit Interleaved Coded Modulation (BICM)

A. LDPC Encoder

The binary input is given to the low density parity check encoder. The low density parity check encoder is an input matrix. The binary values such as 0 and 1 are added to the matrix.so that even if any losses occurred during the transmission of signals, it will affect only the added binary values.so that the error can be reduced

B. Filter

In order to reduce the noise of the signal, the output of the low density parity check (LDPC) encoder is given to the filter Π.Here the bit stream is interleaved in to the complex constellation.

C. Symbol Mapper

To achieve a signal of correct domain and shape, the signal is given to symbol mapper which maps the signal on to the complex constellation

D. Space Frequency Block Coding

If Space time coding (STC) is joined to multi-carrier modulation, such as orthogonal frequency-division multiplexing (OFDM), space frequency block coding (SFBC) can be performed. **S**pace time coding is one of the main methods in order to exploit the capacity of multiple-input multiple-output (MIMO) channels. Since STC techniques use both time and spatial domains for coding data symbols, diversity and spatial multiplexing can be combined achieving robustness at the receiver with a higher data rate transmission. As a result, STC techniques have been incorporated in many of the last-generation wireless communications systems, including the new generation of terrestrial and mobile digital video broadcasting (DVB) standards. This way, code words are fed into adjacent carriers of the two consecutive OFDM symbols, translated to the time domain and transmitted through several transmit antennas. This transmission scheme is usually combined with bit-interleaved coded modulation (BICM) giving good diversity results in a wireless communication link.

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E. IFFT

An N-point IFFT is used to for OFDM modulation and converting the signal to a time domain signal. Before taking the IFFT, zero padding is incorporated which allow selecting different OFDM sizes and allocates any desired number of subcarriers for carrying data and pad the remaining including the centre dc carrier with zeros. Zero padding is necessary to avoid inter-carrier interference (ICI) in OFDM systems showing that using all subcarriers for data is not realistic. The output of IFFT is converted to serial and a cyclic prefix is then added. Since perfect channel state information at receiver has been assumed, training symbols have not been added for synchronization and channel estimation.

RECEIVER SECTION

The receiver performs the reverse process .The receiver section consists of FFT, Soft (Space frequency block coding (SFBC), Filter or Interleaver, low density parity check (LDPC) Decoder, Slicer.

A. FFT

The receiver performs the reverse process. Firstly the cyclic prefixes appended to each OFDM symbol are removed. Then the time domain signal is converted back into frequency domain signal through the FFT process.

B. Soft SFBC Detector

A diversity combiner is used at the receiver for detection. It takes the output from the de-multiplexers at the output of FFT block and performs space frequency block decoding. The output of space frequency block decoder is input to the filter.

C. Filter

The output of soft SFBC (SPACE FREQUENCY BLOCK CODING) detector is given to the filter in order to reduce the noise of the signal.

D. LDPC Decoder

The input from the filter is given to the low density parity check decoder. The low density parity check decoder is also a matrix. Here also the binary values such as 0 and 1 are added to the matrix.so that even if any losses occurred during the transmission of signals, it will affect only the added binary values.so that the error can be reduced. The receiver section performs the reverse process of the transmitter section.

E. Slicer

The slicer is mainly used to reduce the noise of the signal. The slicer slices the noise from the signal. So that finally the output of LDPC decoder is given to the slicer**.**

The PAPR of the OFDM signal X(t) is defined as

$$PARP = P_{PEAK}/P_{AVERAGE} = \max[|x_n|^2] / E[|x_n|^2]$$

Where n x= An OFDM signal after IFFT (Inverse Fast Fourier transform).

E[.] = Expectation operator, it is an average power. The complex baseband OFDM signal for N subcarriers represented as

$$X(T) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n \, e^{j2\pi\Delta f\tau}, \quad 0 \le t \le NT \;\ldots..2$$

III. SLM TECHNIQUE

In selective mapping (SLM) technique the actual transmit signal lowest PAPR is selected from a set of sufficiently different signals which all represents the same information. SLM Technique are very flexible as they do not impose any restriction on modulation applied in the subcarriers or on their number. Block diagram of SLM Technique is shown below.

Let's define data stream after serial to parallel conversion as X=[X0, X1--------,XN-1]T.

Initially each input Xn (u) can be defined as equation $x_n^{(u)} = x_n . b_n^{(u)}$

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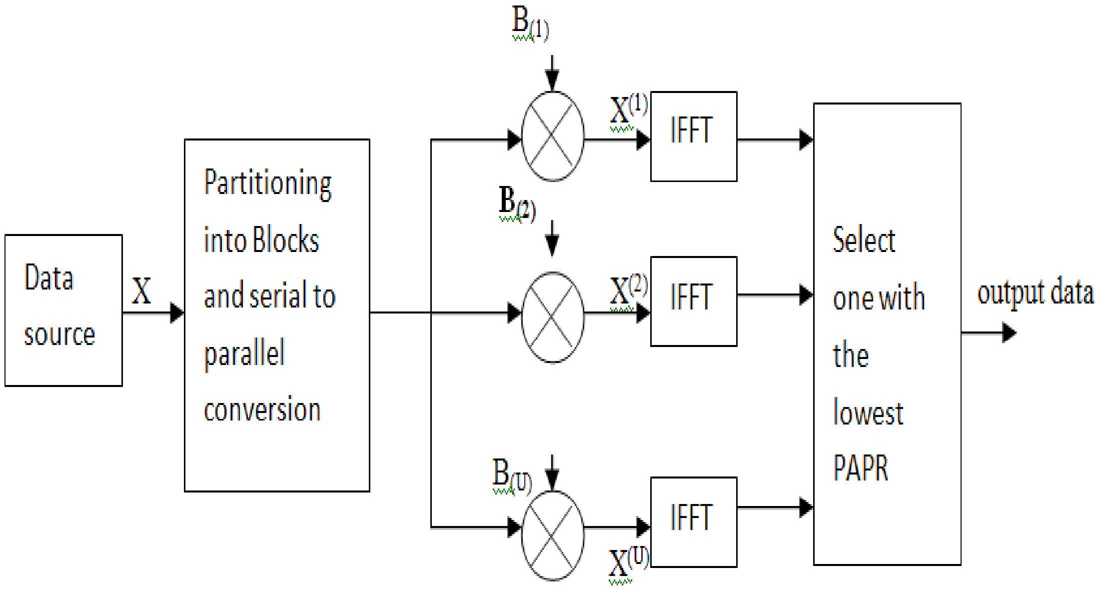

Fig 2:-Block Diagram of OFDM transmitter with the SLM Technique

B(u) can be written a$x_n^{(u)} = [\,x_0^{(u)} .. x_1^{(u)}, \ldots \ldots x_{N-2}^{(u)}]^T$,Where n=0,1,2…..N-1 and u=0,1,2…..Uto make the U phase rotated OFDM data blocks. All U phase rotated OFDM data blocks represented the same information as the unmodified OFDM data block provided that the phase sequence is known. After applying the SLM technique, the complex envelope of the transmitted OFDM signal becomes

$$X(T) = \frac{1}{\sqrt{N}} \sum_{n=0}^{N-1} x_n\, e^{j2\pi\Delta f t} \quad 0 \leq t \leq NT\text{here } \Delta f = \frac{1}{NT}$$

NT is the duration of an OFDM data block. Output data of the lowest PAPR is selected to transmit. PAPR reduction effect will be better as the copy block number U is increased. SLM method effectively reduce PAPR without any signal distortion. But it has higher system complexity and computational burden. This complexity can less by reducing the number of IFFT block. The block diagram of the proposed system is shown in the below figure. The transmitter section consists of BPSK Modulation, Serial to Parallel Conversion and the combination of SLM technique and Clipping and Scaling method. Cyclic Prefix, Discrete Cosine Transform and IFFT together forms the SLM method. Three types of scaling methods are used: - Scale Up, Scale Down and Scale Up and Down.

IV. CLIPPING AND SCALING APPORACH

Normally PAPR is considered to be one of the disadvantage in any ofdm system. Two possible combinations of spatial diversity and OFDM techniques are space-time-block-coded (STBC) OFDM and space-frequency-block coded (SFBC) OFDM systems. Both combinations suffer from high- PAPR problem Here we aim to reduce the papr in sfbc ofdm system using clipping and scaling approach. In this technique, the amplitude of complex OFDM signal is clipped and then scaled in such a way so that the PAPR is reduced without causing much degradation in bit error rate (BER) inevitable for reliable transmission. A number of techniques have been proposed to reduce the PAPR for example clipping, companding, selective mapping (SLM), partial transmit sequences (PTS), tone reservation etc. However, there are some limitations with these techniques. Since different ranges of amplitudes of the signal are scaled in a different manner, it is called Differential Scaling. We have considered three types of scaling as described below.

A. Scale Up:

In this method, we scale up the lower amplitudes of the signal by a factor of β. This leads to increase the average value without affecting the peak values. Therefore, the resulting PAPR reduces. The PAPR reduction function can be defined as

$$h(x) = \alpha xp,\ if\ x > \alpha xp$$

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$= \beta x, \text{ if } x < A = x, \text{ if } A \leq x \leq \alpha xp$

where *xp* is the amplitude peak value occurring in an OFDM symbol block, α is the factor deciding the clipping threshold in terms of percentage of the peak value and β is the scaling factor for the range [0,*A*] whose value is greater than one.

B. Scale Down:

In this method, we scale down the higher amplitudes of the signal by factor of γ. This leads to decrease the peak value. Although the average value would also fall down, the resulting PAPR reduces. Because the reduction in peak power is greater than the reduction in the average power. The PAPR reduction function can be defined as

$$h(x) = \alpha xp, \text{ if } x > \alpha xp = \gamma x, \text{ if } B \leq x \leq \alpha xp$$

$$= x, \text{ if } x < B$$

Where *xp* is the amplitude peak value occurring in an OFDM symbol block, α is the factor deciding the clipping threshold in terms of percentage of the peak value and γ is the scaling factor for the range [$\beta, \alpha xp$] whose value is less than one. The values of the parameters used are mentioned at the end of this section.

C. Scale Up and Down:

In this method, we combine both the above-mentioned approaches i.e. up-scaling and down-scaling. This method exploits the advantages of both the methods. Hence, a PAPR can be reduced considerably. The PAPR reduction function can be defined as

$$h(x) = \alpha xp, \text{ if } x > \alpha xp$$

$$= \gamma x, \text{ if } B \leq x \leq \alpha xp = \beta x, \text{ if } x < A$$

$$= x, \text{ if } A \leq x \leq B$$

where *xp* is the amplitude peak value occurring in an OFDM symbol block, α is the factor deciding the clipping threshold in terms of percentage of the peak value β is the scaling factor for the range [0,*A*] and γ is the scaling factor for the range [$B, \alpha xp$].

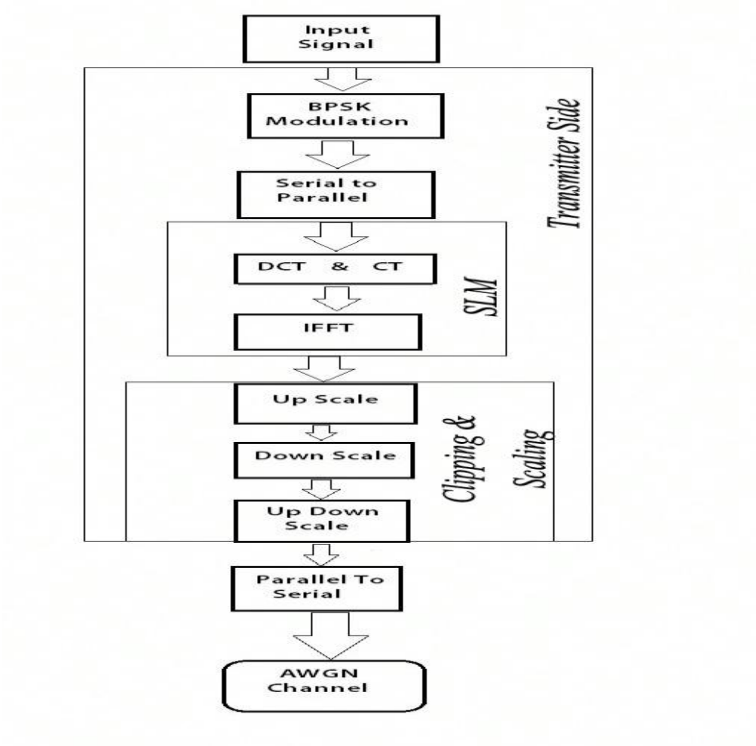

Fig 3:- Transmitter section

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The output of the transmitter section is given AWGN channel and then it is given to receiver section. FFT and Demodulation functions are performed in the Receiver section

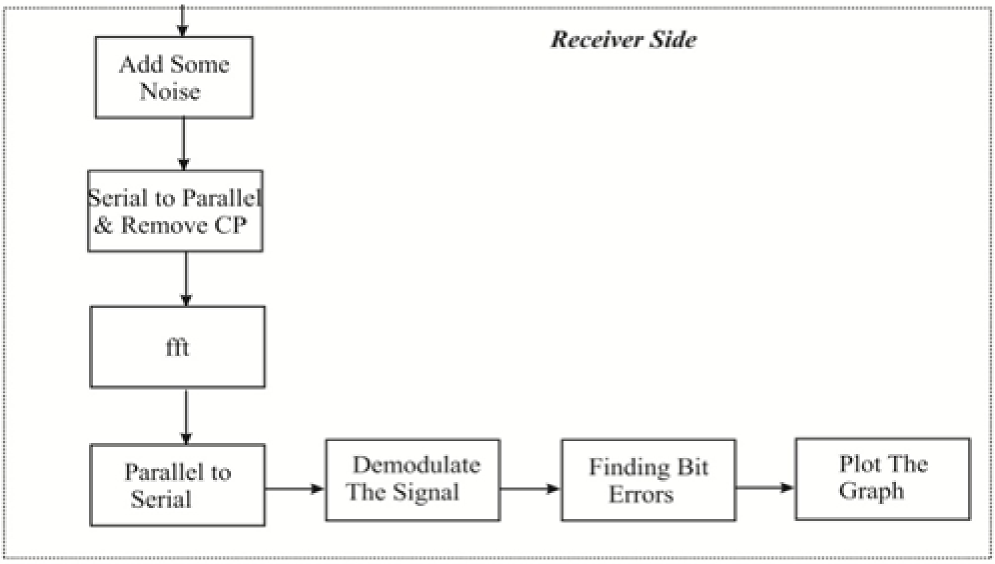

Fig 4: - Receiver section

V. SIMULATION RESULTS

The performance of the overall system has been assessed by means of the bit error rate (BER) after the LDPC decoder. The estimate for each element of the selected phase sequence is obtained by dividing the received check symbol (which is phase rotated due to the phase sequence) by the estimated check symbol of the corresponding position. The estimate for the selected phase sequence is obtained by finding a phase sequence that is the closest to the phase sequence estimate among all possible candidates. The DVB-T2 parameters used in the simulations are: 64800 bits of length of the LDPC block, $R = 2/3$ of LDPC code rate, 16-QAM modulation, 2048 carriers as FFT size and 1/4 of guard interval. The simulations have been carried out over a Rayleigh channel (Typical Urban of six path, TU6), commonly used as the simulation environment for terrestrial digital television systems. Perfect CSI has been considered at the receiver.

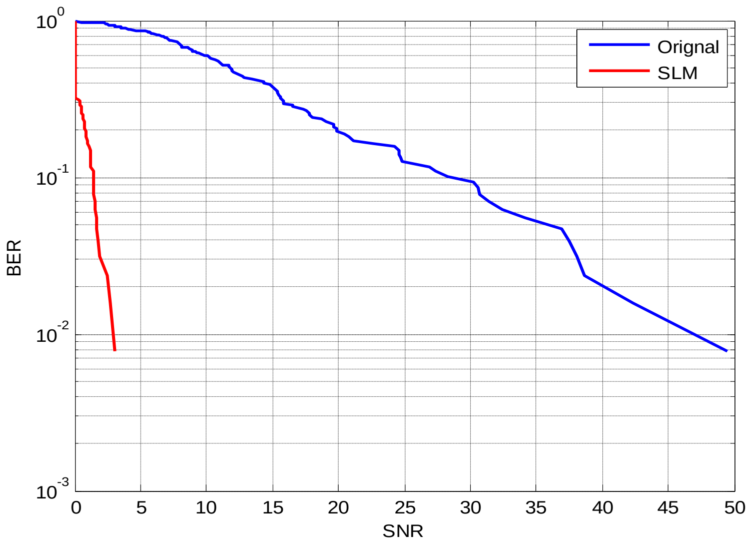

Fig 5:- Bit Error Rate (BER) vs. Signal to Noise Ratio (SNR)

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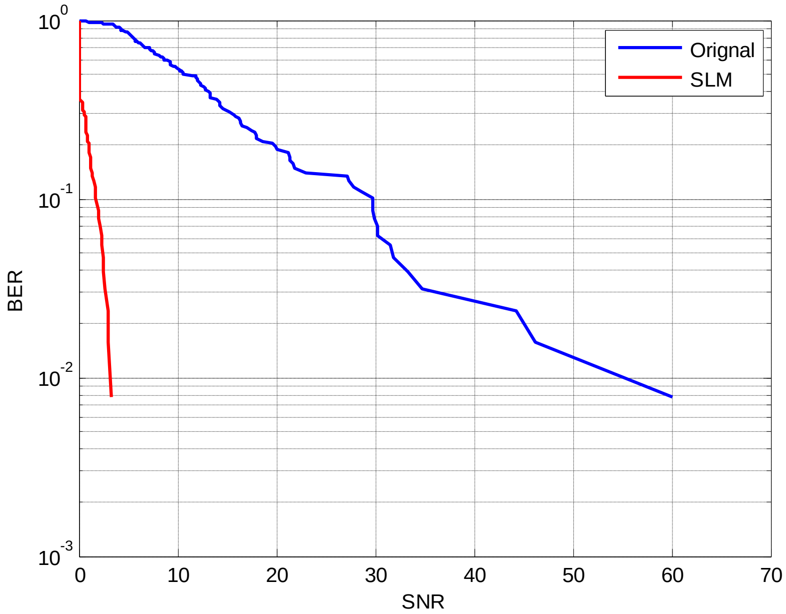

Fig 6:- Bit Error Rate (BER) vs. Signal to Noise Ratio (SNR)

VI. CONCLUSION

In this paper, we proposed a combination of SLM technique and clipping & scaling method for the PAPR reduction of coded OFDM signal. By appropriately embedding the phase sequence information on the check symbols of the coded OFDM data block, we can achieve both PAPR reduction from the SLM technique and error performance improvement from the channel coding with no loss in data rate. The modified selective mapping technique is mainly used to improve the performance of the OFDM system with respective PAPR. This scheme requires only one IFFT block at the transmitter. Results of simulation of modified SLM technique show that the PAPR reduction of OFDM system, which further results in high performance of wireless communication. With the rising demand for efficient frequency spectrum utilization, OFDM proves invaluable to next-generation communication systems.

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