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Power Reduction Using ACE and NN Schemes

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Abstract: ***Orthogonal Frequency Division Multiplexing abbreviated as OFDM is a method of encoding digital data on multiple carrier frequencies. Along with several advantages, ofdm has a main drawback of having high peak-to-average-power ratio (PAPR).This occurs mainly because of the superposition of subcarrier signals used in ofdm system. We have to reduce this peak-to-average-power ratio and hence here a scheme called active constellation extension (ACE) along with the concepts of neural networks is introduced. Also we present analytical results in comparison with simulations.***

Keywords: OFDM, ACE, NN, Peak-to-average-power ratio, BER

1. Introduction

One of the widely used digital multi-carrier modulation technique is the orthogonal frequency division multiplexing. The important properties of OFDM includes high spectral efficiency, robustness against ISI and fading caused by multipath propagation, low sensitivity to time synchronization errors and facilitates transmitter macro diversity. A large number of closely spaced orthogonal sub-carrier signals are used to carry data in OFDM. The orthogonality prevents cross talk between signals. Owing to above advantages, one of the main disadvantages of an OFDM system is its high PAPR value. This disadvantage can be reduced with the help of active constellation extension technique that uses the concept of neural networks also. In the proposed ACE method, constellation points are moved such that the PAPR is reduced ,but the minimum distance of constellation points does not decrease .As a result, receiver BER does not increase for a slight increase in power .Neural networks are used both at the transmitting and the receiving ends. Artificial neural networks are used here to process information at a great speed.

2. Existing Scheme

There are many techniques exists for PAPR reduction in OFDM systems. Here we are considering the traditional ACE scheme and time-frequency neural network (TFNN) scheme and then compares their performance with proposed technique. In ACE scheme, both time domain and frequency domain signal processing is required. The main idea behind active constellation extension is to shift the outer constellation points towards exterior of original constellation generating an alternative representation of the same symbol. As a result PAPR can be reduced with low BER. Here, time domain signal clipping and frequency domain constellation point extension are considered. Signal clipping is done for reducing signal peaks with magnitudes higher than the target peak level. Hence the main drawback of ACE scheme is the large number of IDFT and DFT operations.

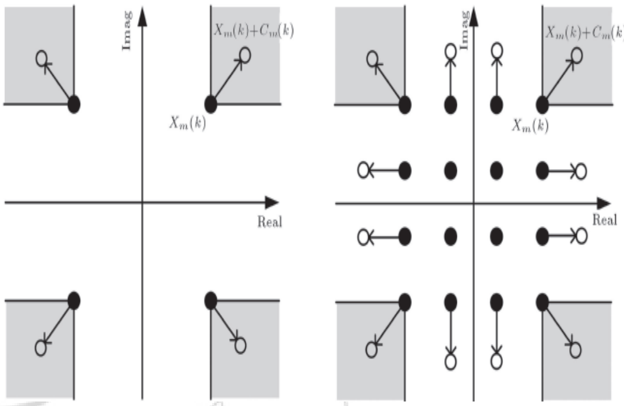


Figure 1: Active constellation extension in QPSK and 16QAM

Another scheme that exists for PAPR reduction is the time frequency neural network. TFNN uses complex frequency domain neural network modules for PAPR reduction. Hence comparing with ACE scheme, TFNN scheme also achieves an equivalent power reduction. While considering higher order modulation fading channels, TFNN technique shows a poor bit error rate (BER) performance. The scheme also requires a large number of complex and real computational operations. Thus we have to propose a new method that can reduce peak-to-average-power ratio and achieves a better BER at the same time with lower complexity.

3. Proposed Work

3.1 PAPR

In this paper a new PAPR reduction technique based on ACE and neural networks is considered. PAPR is the ratio of maximum power to average power. It mainly occurs in multiple carrier frequency systems. As it is a power ratio, it is normally expressed in decibels (dB).For OFDM, PAPR is approximately equivalent to 12dB. PAPR of the can be expressed as:

$$\mathrm{PAPRdB} = 10\log\left(\frac{\max[x(t)\,x^*(t)]}{E[x(t)\,x^*(t)]}\right) \quad (1)$$

where ()* represents the conjugate operator and E[.] denotes the expectation operator.

As a performance measure, complementary cumulative distribution function (CCDF) is used to evaluate the PAPR reduction technique performance. The CCDF curve shows the amount of time a signal spends above average power level of measured signal. That is, CCDF is the probability that the signal power will be above the average power level. CCDF can be simply represented as:

$$CCDF_{PAPR} = \Pr(PAPR > PAPR_o) \qquad (2)$$

where PAPRo denotes a given threshold level.

3.2 Neural Networks

Inter connected group of nodes is termed as networks. These nodes can be considered as computational units. These nodes receive inputs and process them to obtain an output. If the network sees the nodes as artificial neurons, they are termed as artificial neural networks (ANN). ANNs combine artificial neurons in order to process information.

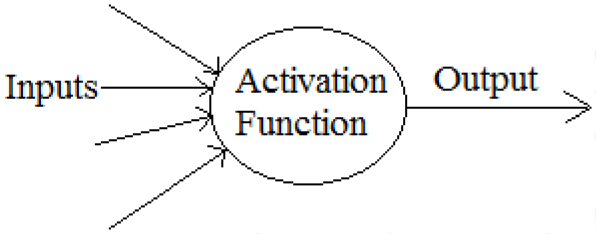


Figure 2: An artificial neuron

The NNs considered here are based on the multilayer feed forward network. That is, with two layers and two neurons per each layer with triangular activation function. Triangular basis transfer function is a neural transfer function that calculate a layers output from its net inputs. Here, NNs are employed both at receiver and transmitter. Since neural networks are adaptable there is no need for a priori mathematical model for input-output transformation. Hence neural networks are not programmed but trained.

3.3 System Model

In the proposed system, the main components used are a modulator arrangement, serial to parallel or a parallel to serial converter, FFT or IFFT and NNs. The block of N data symbol from source is modulated by using either a QPSK or QAM modulator. Both are quadrature modulation schemes and hence we can encode two bits per symbol and thus to minimize BER. Then we have to obtain time domain OFDM signal through N-point IFFT operation. Clip sample peaks which are above threshold level and then constellation extension is carried out.

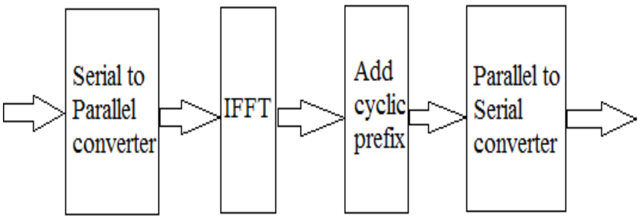


Figure 3: OFDM transmitter

At the receiver, reverse operations are carried out to recover the original data. A Rayleigh fading channel with perfect channel estimation is assumed at the receiver. A channel equalizer is also used at the receiver end for adjusting the balance between several frequency components within the signal through equalization. The process of transforming from time domain representation to frequency domain, we use FFT operation.

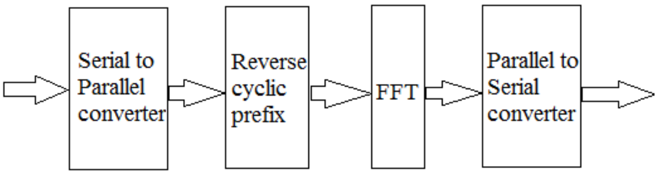
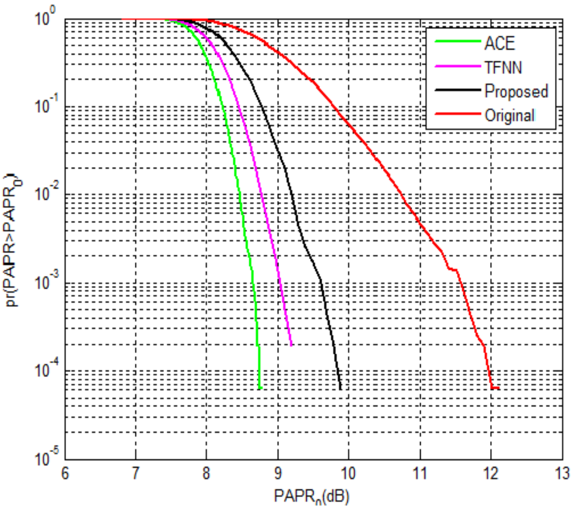


Figure 4: OFDM receiver

4. Simulation Results

4.1 PAPR performance analysis

For evaluating the PAPR performance, we have to plot complementary cumulative distribution function across the clip level PAPRo. Simulation results can be obtained for ACE,TFNN, prposed and original OFDM using matlab. We can observed that the OFDM system exhibits a very large value of peak-to-average-power ratio. Also the TFNN scheme offers better PAPR reduction compairing to proposed for low clip level values. If we analyse the value of PAPRo at 10^(-3) CCDF, the clip level for TFNN is 9dB and for proposed it is about 9.6dB. That is, only a small variation occurs between TFNN scheme and the proposed scheme.



. **Figure 5:** CCDF of PAPR plot of different schemes with N=128, L=20 and 16QAM modulation

4.2 BER Performance Analysis

BER stands for bit error rate and here, it is plotted across signal to noise ratio in dB. BER performance in the case of QPSK and 16 QAM modulation are plotted separately for each schemes. In QPSK, from the simulation output we can see that a significant BER degradation is observed for the proposed scheme compared to others. When Eb/No=10dB,BER for proposed scheme and TFNN scheme shows better performances.

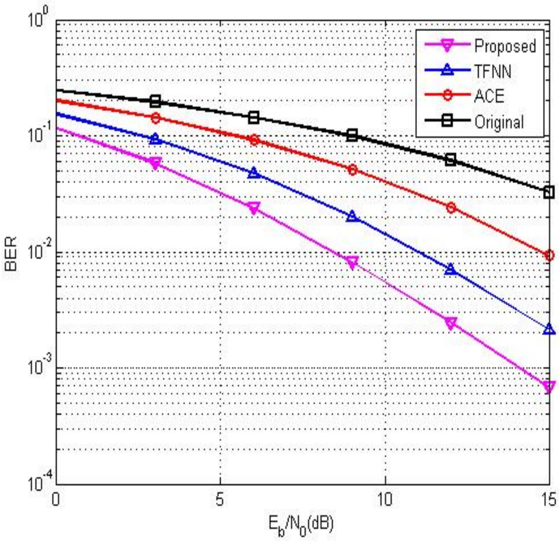


Figure 6: BER performance of different schemes with N=128, L=20 and QPSK

However, while considering higher order modulation such as 16 QAM, a significant BER degradation is obtained for proposed than the TFNN. If we are considering Eb/No=20dB , there exist a great variation of BER between TFNN and proposed NN scheme. Hence we can say that, for all modulation techniques, proposed scheme shows a good BER degradation.

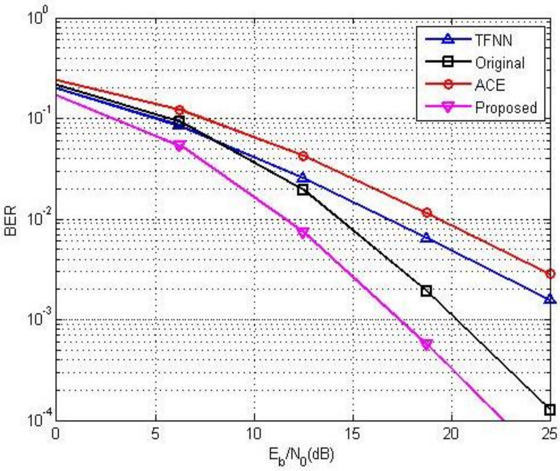


Figure 7: BER performance of different schemes with N=128,L=20 and 16 QAM

5. Conclusion

In this paper, we introduce a new approach to overcome the high peak-to-average-power ratio problem in OFDM systems. The scheme proposed in this work is termed as active constellation extension which is based on neural networks. Neural networks are used both at transmitter and receiver sides and hence computational complexity can be reduced. From the simulations obtained, we can conclude that proposed method is the most suited one for PAPR reduction with better BER performance and lower complexity compared to other PAPR reduction methods.

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