Performance Optimization of OFDM Communication Systems Using Artificial Neural Networks

N. P. Giradkar
Professor SRPCOE,Nagpur

C.D. Raut,
Research Scholar SRPCE, Nagpur

ABSTRACT

In order to combat fading in an OFDM communications system, adaptive modulation techniques have been employed which can improve the performance. We propose that an artificial neural network (ANN) can be inserted in an OFDM system that would provide the information necessary to perform an adaptive modulation of the subcarriers. The performance of the system is evaluated in terms of symbol error probability. The results of our simulations allow us to validate our hypothesis. Multicarrier signals are known to suffer from a high peak-to-average power ratio, caused by the addition of a large number of independently modulated subcarriers in parallel at the transmitter. When subjected to a peak-limiting channel, such as a nonlinear power amplifier, these signals may undergo significant spectral distortion, leading to both in-band and out-of-band interference, and an associated degradation in system performance [1], [2]. This paper characterizes the distortion caused by the clipping of multicarrier signals in a peak-limiting (nonlinear) channel. Rather than modeling the effects of distortion as additive noise, as is widespread in the literature, we identify clipping as a rare event and focus on evaluating system performance based on the conditional probability of bit error given the occurrence of such an event [4]. Our analysis is Based on the asymptotic properties of the large excursions of a stationary Gaussian process, and offers important insights into both the true nature of clipping distortion, as well as the consequent design of schemes to alleviate this problem[10], [11].

Index Terms—Clipping, OFDM, peak-to-average ratio. 802.11a WLAN network ,ANN network.

1. INTRODUCTION

In recent years, Orthogonal Frequency Division Multiplexing (OFDM) has been adopted in many communication standards including broadband ADSL modems, digital video broadcasting (DVB), and digital audio broadcasting (DAB) for digital radio. In general OFDM can be made immune to multipath fading by using a frequency domain one-tap equalizer if the delay of the longest multipath is less than the guard interval (Tg). The purpose of this equalizer is to correct the amplitude and the phase of each sub-carrier of OFDM signal by simply multiplying the OFDM spectrum by the value of the channel impulse response at the subcarrier frequency [1]. It can be shown that in the case of differential PSK coding, such as DQPSK used in DAB, the need for the one tap equalizer is also eliminated because the channel channel impulse response for a particular sub-carrier is almost constant for consecutive OFDM symbols provided that the fading is slow (i.e. Doppler spread is small compared with the sub-carrier spacing). However, broadcast DAB signals in the UK have been observed to have multipath delays that exceed the guard interval resulting in significant performance degradation due to both inter-symbol (ISI) and inter-subcarrier interference (ISCI). For instance, in DAB transmission mode I, signals received from transmitters that are further than 74 km cause delays longer than $Tg(= 246\ \mu s)$ at the receiver. The performance of OFDM systems in the presence of phase noise has been analyzed in several works [3]–[7].

2. BLOCK DIAGRAM OF OFDM USING ANN:-

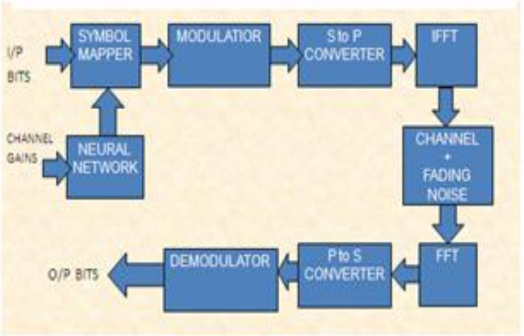

Fig. 1 – Schematic of OFDM using ANN

3. METHODS OF OPTIMIZATION

Neural networks are dynamic systems of a large number of connected data sensing units and simple processing units known as preceptors and neurons respectively (see Figure 1). Each neuron of this network can be considered as an operator, receiving real numbers as input and transforming them into one output value. The output is transmitted by links to connect the neurons. On each link a real number, the weight, is defined. Before an output value is transmitted, it is multiplied by the corresponding weight. Thus the weight reflects the strength of the individual connections see (figure 1) [7]. Modifying the weight values by repeated application of learning rules allows the network to approximate the mapping function, which maps the input space (domain) into the desired output space (range).

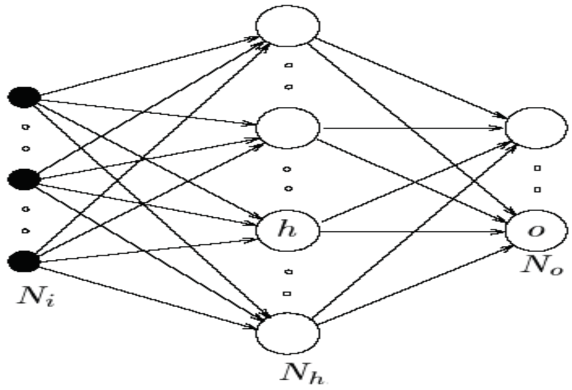

Fig. 2 - Multilayer feed forward NN.

4. USE OF NEURAL NETWORK

Neural networks are dynamic systems of a large number of connected data sensing units and simple processing units known as preceptors and neurons respectively (see Figure 1). Each neuron of this network can be considered as an operator, receiving real numbers as input and transforming them into one output value. The output is transmitted by links to connect the neurons. On each link a real number, the weight, is defined. Before an output value is transmitted, it is multiplied by the corresponding weight. Thus the weight reflects the strength of the individual connections see (figure 2) [13]. Modifying the weight values by repeated application of learning rules allows the network to approximate the mapping function, which maps the input space (domain) into the desired output space (range). Neural networks (NNs), on the other hand, can be used as simple function approximates with a predetermined response time regardless of how complex the function is. This motivated us to study the feasibility of using NN as a pulse shape generator in an adaptive pulse shaping NDC-TOE system. This paper describes the use of NNs for such task, where in computed as output a channel impulse response (CIR) is the input and a pulse shape that minimizes the NDC-TOE error is computed as output.

5. OVERVIEW OF 802.11x WLAN

The OFDM system used in IEEE 802.11a provides a WLAN with data payload communication capabilities of 6, 9, 12, 18, 24, 36, 48, and 54 Mbps. The block diagram of 802.11a system is shown in figure 3..The system uses 52 sub carriers that are modulated using binary or quadrature phase shift keying (BPSK/QPSK), 16-quadrature amplitude modulation (QAM), or 64-QAM. Forward error correction coding (Convolution coding) is used with a coding rate of 1/2, 2/3, or 3/4. At the transmitter, binary input data is encoded by the industry standard rate 1/2, constraint length 7, code with generator polynomials (133,171). The rate may be increased to 2/3 or 3/4 by puncturing the coded output bits. After interleaving, bits are mapped into complex numbers according to the modulation scheme that is being used. In order to facilitate coherent reception, four pilot values are added to each of the 48 data values, such that a total of 52 modulation values are reached per OFDM symbol. 52 values are then modulated onto 52 sub carriers by applying and Inverse Fast Fourier Transform (IFFT). A guard interval (cyclic prefix) is added to make the system robust to multipath propagation. Next, windowing is applied to attain a narrower output spectrum. The modulated and windowed digital output signals are converted to analog signals, which are then up converted to the proper channel in the 5 GHz band, amplified, and transmitted through an antenna. A typical OFDM receiver basically performs the reverse operations of the transmitter, together with additional training tasks. First, the receiver has to estimate frequency offset and symbol timing, using special training symbols in the preamble. Then, it can do a Fast Fourier Transform (FFT) for every OFDM symbol to recover 52 modulation values of all subcarriers. The training symbols and pilot subcarriers are used to correct for the channel response as well as any remaining phase drift. After taking FFT, a Viterbi decoder can be used to decode the information sequence with a trace back path of 34. A low complexity soft decision Viterbi decoder for a bit-interleaved system can be easily implemented. The preamble is composed of 10 repetitions of a “short training” sequence, and two repetitions of a “long training sequence”. At the receiver end, short training sequences are used for Automatic Gain Control (AGC) convergence, diversity selection, timing acquisition, and coarse frequency acquisition in the receiver. Long training sequences are used for channel estimation and frequency acquisition.

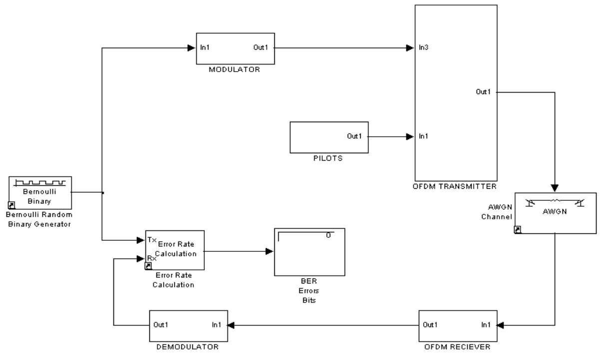

Fig. 3 Block diagram of Implemented 802.11a WLAN

6. IEEE 802.11 PHY LAYRES

A fourth 802.11 PHY is defined by IEEE’s 802.11a standards: The Coded Orthogonal Frequency Division Multiplexing (COFDM) layer is capable of transmitting data at 54 Mbps by using the broader 5-GHz band. However, FCC regulations limit the transmission power used at these higher frequencies, and thus it reduces the distance higher-frequency transmissions can travel. For these reasons, radios that use COFDM technology must be closer together than those using the other PHY introduced above. The obvious benefit of COFDM is speed. • The sixth 802.11 PHY is detailed in the IEEE 802.11g standards and is backward compatible with 802.11b. The Orthogonal Frequency Division Multiplexing (OFDM) PHY allows 54 Mbps data rates in the 2.4-MHz band. The speed of transmission under OFDM and COFDM is sufficient to carry voice and image data fast enough for most users.

Sr. No.	Schemes	Band	Speed
1.	DSSS	2.4 GHz	1 or 2 Mbps
2.	FHSS	2.4 GHz	1 or 2 Mbps
3.	DFIR	850 to 950 nm (infrared)	None implemented
4.	COFDM	5 GHz	54 Mbps
5.	HR/DSSS	2.4 GHz	5.5 or 11 Mbps
6.	OFDM	2.4 GHz	54 Mbps

Table 1- List of IEEE 802.11 PHY Layer

7. EXPERIMENTAL STUDY

This simulation is done with Mat lab and Simulink as the tool. The simulation model is designed for AWGN channel with different modulation technique such as BPSK, QPSK,16 QAM, and 64 QAM using ½ and 3/4 code rate. Table 1- List of IEEE 802.11 PHY Layer 802.11a standard, which we used for simulation. The 64 QAM scheme is simulated for 2/3 code rate instead of ½ code rate.

8. STEPS OF SIMULATION

1. Designed eight simulation models for AWGN channel conditions, four for ½ code rate and four for ¾ code rate of all four modulation scheme. Simulated these entire eight simulation model using MATLAB programming code and evaluated the performance using BER Vs SNR plot.
2. Simulated two simulation models for different code rate of each modulation scheme for same channel conditions using programming and evaluated the performance using BER Vs SNR plot.

9. CONCLUSION

In this paper , We have examined the performance of the OFDM based IEEE 802.11aWLAN under AWGN fading channel condition with different modulation scheme (BPSK, QPSK, 16 QAM, 64 QAM) and code rate (1/2, 2/3, 3/4). While transmitting the signal in practical fading environmental condition, multipath fading effects occurs which causes the inter symbol interference. The effect of intersymbol interference can be reduced by using Guard interval and system performance can be improved .However from the performance, it concludes that BPSK performance is superior as compared to other schemes in noisy channel. The tolerable delay spread matches the time of the cyclic extension of the guard period, the BER rises rapidly due to the inter symbol interference. From the obtained experimental and simulation results, one can see that the outdoor multipath characteristics at 5.2 GHz with moving units cannot be considered constant over the one OFDM frame and, consequently, updating the channel estimates at the beginning of each frame, as currently recommended by the IEEE 802.11a standard, is not enough to accurately compensate multipath effects.

10. RESULTS & DISCUSSION

1. AWGN Channel for 1/2 Code Rate

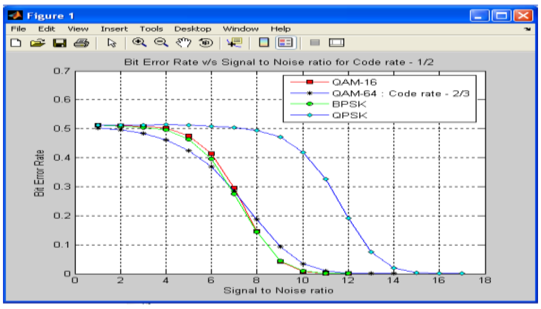

Fig.4– BER Vs SNR plot for ½ code rate

2. AWGN Channel for 3/4 Code Rate

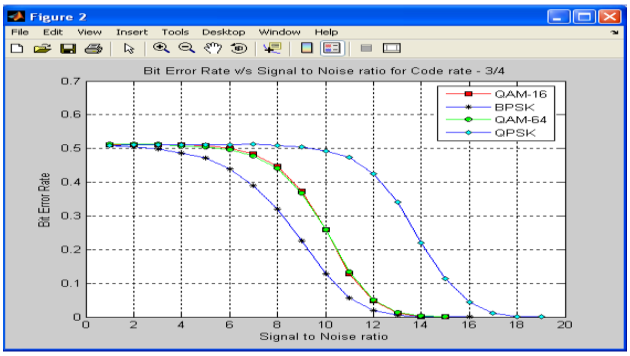

Fig.5 – BER Vs SNR plot for 3/4 code rate

By simulation using AWGN Channel for ½ and ¾ code rate , it is found that the performance of BPSK modulation scheme is better than other modulation scheme such as QPSK, 16QAM and 64QAM as per the BER Vs SNR plot obtained shown in figure 4 By comparing the result with two different coding rate for BPSK, QPSK, QAM16 and QAM-64 for coding rate ½ (2/3 for QAM-64) and ¾ as shown in figure , it is found that the performance of all the systems is better for ½ (2/3 for QAM-64) code rate as compared to ¾ code rate.

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