

# Multi Carrier Symbol Recovery in OFDM using ANN in Wireless Channel

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**Abstract** - Orthogonal Frequency Division Multiplexing (OFDM) is a special type of multicarrier technique where a single data stream is transmitted over a number of low rate sub carriers. OFDM has been adopted as the modulation method of choice for practically all the new wireless technologies being used and developed today. But symbol recovery is still a problem area in OFDM. We have used an Artificial Neural Network (ANN) for recovery of symbols transmitted using different sub-carriers in OFDM. The investigation is made in the multipath fading environment using different modulation techniques. The ANN is trained to recover symbols transmitted using different modulation schemes and with multiple subcarriers. The experimental results derived show the effectiveness of the model proposed.

**Keywords** - OFDM, Multicarrier, spectral efficiency.

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## I. INTRODUCTION

OFDM i.e. orthogonal frequency division multiplexing is a multicarrier transmission technique. OFDM is based on the concept of frequency-division multiplexing (FDD), the method of transmitting multiple data streams over a common broadband medium. That medium could be radio spectrum, coax cable, twisted pair, or fiber-optic cable [1]. Each data stream is modulated onto multiple adjacent carriers within the bandwidth of the medium, and all are transmitted simultaneously. In this method the serial digital data stream to be transmitted is split into multiple slower data streams, and each is modulated onto a separate carrier in the allotted spectrum. These carriers are called subcarriers or tones. The modulation can be any form of modulation used with digital data, but the most common are binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), and quadrature amplitude modulation (QAM) [6]. The outputs of all the modulators are linearly summed, and the result is the signal to be transmitted. In this case the OFDM symbols are tried to recover at the receiver after passing through different sub channels. It is quite difficult to recover the symbols in OFDM. The multipath noisy fading environment causes a lot of error in implementing such scheme. ANN based system works a lot in trouble shooting in this regard It could be up converted and amplified if needed. OFDM as multiplexing technique.

OFDM can be seen as the modulation or multiplexing technique. One of the main reason for using OFDM as the multiplexing technique is that it is robustness against frequency selective fading. In a single carrier system, the single carrier may interfere or failed, but in multicarrier this possibility is very less. Error correction coding is used for those subcarriers. The parallel data transmission schemes scheme is started during mid 1960s. Since then parallel data transfer and frequency division method is applicable.

It is better to use non overlapping channels for reducing interference, but this causes wastage of spectra. This disadvantage leads to rising of OFDM as the multicarrier modulation techniques which uses spectrum efficiently. Since OFDM has the cyclic prefix concept so it reduces interference in frequency fading environment. The multi carrier environment leads to less BER. But it is not easy for recovery of symbols in subcarriers having modulated with different schemes in OFDM system in general case. So in this case Artificial Neural Network works as an effective method for computing error in the received bits. We used ANN for symbols recovery. We apply ANN where we trained the system with OFDM modulated data and tested with different states of data. Thus we try to recover the symbols in an efficient manner.

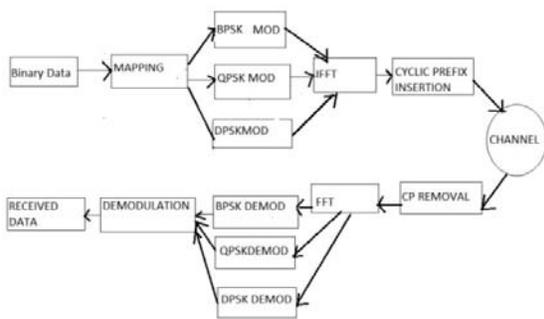


Fig. 1 : Process flow diagram of present work.

## II. PRESENT SYSTEM

Our present work confined in the generation of OFDM symbol in the wireless channel in fading environment consideration. We have simulated OFDM signal in multi modulation situation as shown in fig1. We mapped binary data stream into three different types of modulation schemes such as BPSK, QPSK and DPSK individually as well as in combined process as shown in the fig2. At the outset we divided whole input data stream into three different modulation techniques such as BPSK, QPSK and DPSK individually. Then the modulated data set may be of BPSK, QPSK or DPSK is converted to serial to parallel. After serial to parallel conversion these modulated dataset is passed into IFFT block thus we got our BPSK modulated OFDM signal and then thereafter cyclic prefix are added. After onwards we pass it to the fading channel both Rayleigh and Rician. In the receiver portion, after cyclic prefix removal and passing through FFT block we obtain symbols which are disturbed by noises in the channel. The erroneous noisy data is then converted to serial form and passed through the demodulation block. In the demodulation block the demodulation is done, thus we obtained the BPSK demodulated data. Which are received bits in the receiver. Thus demodulated block provides decoded bits or data. Thus symbols are recovered at the receiver. Then at last we compare the Bit Error between the input bits and received bits. We apply matlab and ANN for computing Bit Error Curve. We have used 520 input nodes and our length of FFT is 64 and Number of carriers is 52.

In our next case, we apply the three modulation schemes like BPSK, QPSK and DPSK combined in the system as shown in the fig2. At first random input bits are taken at the transmitter. Then thereafter splitting of data sets are done i.e like we have in our case no. of bits per system is 65. So we divide 1<sup>st</sup> 13 bits to BPSK modulation, next 26 bits to QPSK modulation and last 26 bits for DPSK modulation. Thus all data sets of 65

bits are divided into three sets of different sets of modulation. Then all the modulated bits are summed up and passed through IFFT block. This gives the combined modulated OFDM signal. Then there after cyclic prefix is inserted. After that this combined modulated OFDM signal is passed through the Rayleigh fading channel. The noisy combine modulated OFDM signal after passing through the channel, received at the receiver. In the receiver, cyclic prefix are removed and passed through the FFT block. Thus the modulated signals are converted to frequency domain. After that combined modulated OFDM bits demodulated separately at the Demodulation block and then all are summed up and we got demodulated OFDM symbol. Thus bits are recovered at the receiver. Finally we have calculated bit error between input bits and the received bits. In this way BER are calculated. Thus BER curves are drawn varying SNR (Signal To Noise Ratio). We have done whole process using ANN as soft computing techniques also.

## III. APPLICATION OF Artificial neural networks (ANNs)

Artificial neural networks (ANNs) are one of the popular branches of artificial intelligence. They have very simple neuron-like processing elements (called nodes or artificial neurons) connected to each other by weighting [3]. The weights on each connection can be dynamically adjusted until the desired output is generated for a given input. An artificial neuron model consists of a linear combination followed by an activation function. Different types of activation functions can be utilized for the network; however, the common ones, which are sufficient for most applications, are the sigmoidal and hyperbolic tangent functions.

Neural networks contain neurons with nonlinear activation functions in the input layer and the hidden layer and neurons with linear activation functions in the output layer. ANN has MLP structure, which uses forward propagation neural network. Various training algorithms exist for MLP.

In our 1<sup>st</sup> case we have simulated BER in individually modulated OFDM signal like BPSK. We recover the OFDM symbol at the receiver. For ANN the symbols after IFFT block, those are BPSK modulated are taken as the training data set. The data after passing through channel are taken as targets. With these we have trained the network for varying SNR. There after we have tested the network with different OFDM data sets. These tested data are demodulated and with these BER is calculated. The table1 is for ANN simulation for individually modulated scheme.

In our combined system as shown in the Fig2 the dataset is first splitted into three sub-parts and modulated with BPSK, QPSK and DPSK as described in section III. In this way we recovered the symbols in the receiver. For ANN we take data sets coming out from IFFT block as Training data set. The targets are the data which are taken at the receiver after passing through the fading channel. In this case it is Rayleigh. After this testing procedure is done with different OFDM data sets. The tested data sets are demodulated and decoded and BER is calculated. The table2 is for combined modulated scheme.

For ANN simulation signal  $x_i$  is OFDM signal which is affected by channel impact. Before demodulation, a channel estimation technique should be applied to the signal. At the beginning of the estimation process, this complex signal is split into two parts: real and imaginary. These parts are normalized between 1 and 0 before training. Each part is trained and estimated at different neural network. Real part of signal is trained and estimated at NNR and imaginary part of signal is trained and estimated at NNI. After training and estimation, these components are merged again and demodulated.

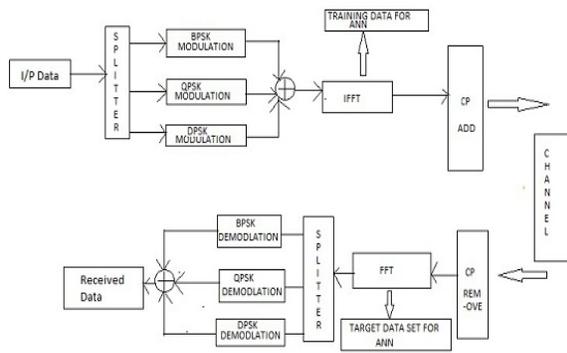


Fig2. Block diagram of combined modulated OFDM system

The estimated output of the system is given as

$$Y_K = NNR(R[X_K] + jNNI(I_m[X_K]))$$

where NNR is Neural Net Real and Neural Net Imaginary.

Table1. Parameters for Artificial Neural Network for individual modulation scheme.

ANN	MLP
Data set size	Training $520 \times 21$ Testing $520 \times 1$
Training type	traingdx
Transfer Functions	Input- logsig. Hidden Layer-tansig. Output- logsig

Maximum No. of epochs	5000
Iterations at Performance goal reached	a. BPSK- 206 b. QPSK- 168 c. DPSK- 217

Table 2. Parameters for Artificial Neural Network for Combined modulation scheme.

ANN	MLP
Data set size	Training $650 \times 21$ Testing $650 \times 1$
Training type	traingdx
Transfer Functions	Input- logsig. Hidden Layer-tansig. Output- logsig
Maximum No. of epochs	5000
Iterations at Performance goal reached	224

#### IV. PROBLEM FORMULATION

We have obtained certain obstructions in our path:

- Implementing all the modulation schemes together in the subcarriers in multipath environment
- Applying ANN to combined modulations OFDM signal.

#### V. RESULTS AND DISCUSSION

We have simulated BPSK, QPSK, DPSK modulated OFDM signal passing through in Rayleigh Channel. Frequency selective fading caused by multipath leads to attenuation at the receiver. In this project, to increase the system performance ANN base channel estimation technique is applied.

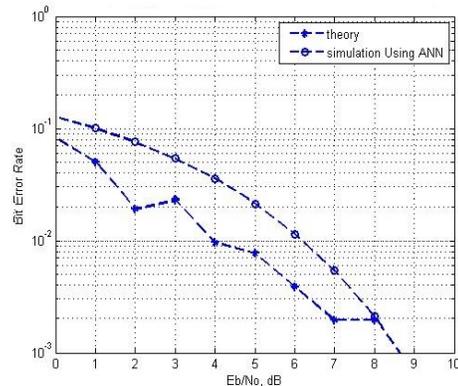


Fig. 3: BER curve for BPSK in OFDM using ANN

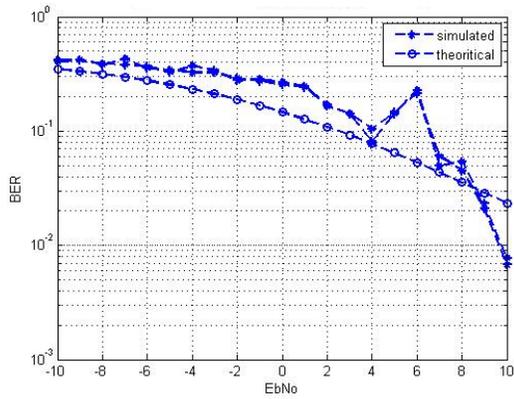


Fig. 4: BER curve for QPSK in OFDM using ANN

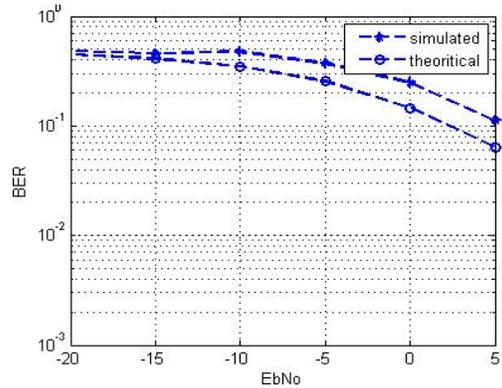


Fig. 7 : BER curve for combined modulated OFDM

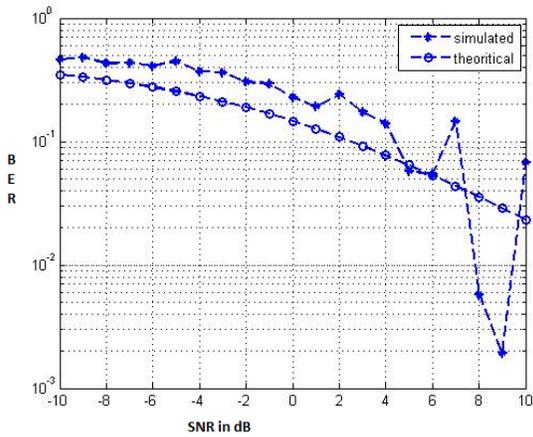


Fig. 5 : BER curve for DPSK in OFDM signal in Rayleigh channel.

It has been seen that ANN based channel estimator works a lot. We have seen that in the case of BPSK at nearly 7dB SNR Bit Error Rate (BER) becomes  $10^{-3}$  while in the case of DPSK and QPSK it reaches  $10^{-2}$  at 10 and 9 dB respectively in Rayleigh environment. Thus we have observed that best performance is obtained in BPSK modulation. We have also observed that combined modulation of BPSK,QPSK and DPSK probability error curve shows less than  $10^{-1}$  error which nearly equals to the theoretical curve of BER as shown in Fig7.We have seen that individual modulated schemes in Combined OFDM with ANN gives BER upto  $10^{-2}$  at nearly 5 db SNR as shown in Fig 8. Thus ANN works a lot.

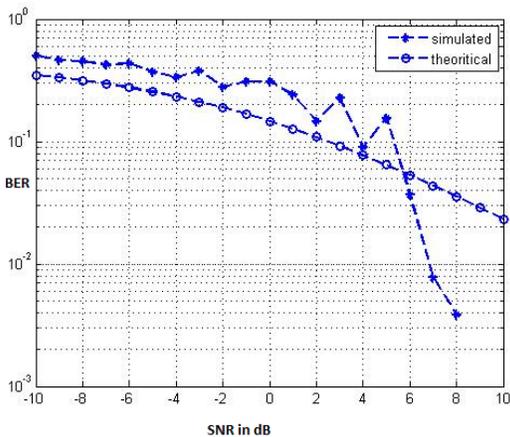


Fig. 6 : BER curve for DPSK in OFDM signal in Rician channel using ANN.

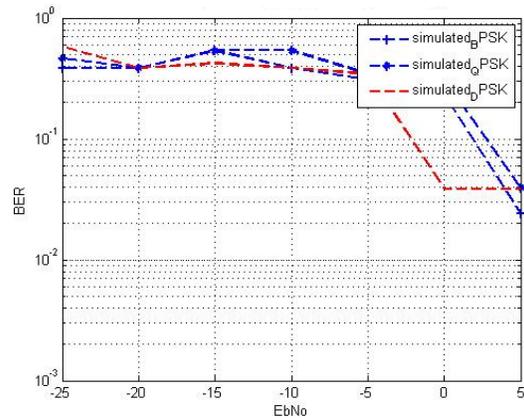


Fig. 8 : BER curve for individual modulation scheme in combined system.

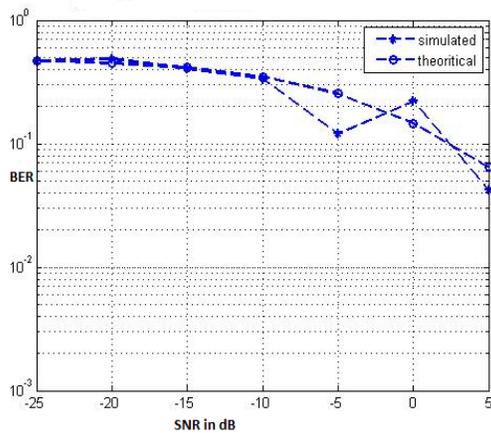


Fig. 9 : BER curve for combined modulated OFDM system with ANN.

## VI. CONCLUSION

We have observed that the Application of ANN for Rayleigh multipath fading channel in multi modulated environment may come to an effective way to improve the BER probability in OFDM system. It shows ANN transforms to be a suitable tool which makes channel estimation better as well as received data performance is significantly good in wireless communication. The ANN with its ability to learn though helps in identifying channel properties and responses suffers from the fact that when the nearby samples have greater correlation the learning stops. ANNs specially feed-forward networks- the type used in this work is the worst sufferers if proper care is not taken [4]. With better configuration of the ANNs and optimized conditions of training and testing, the ANN can be used as the efficient method for recovery of symbols at different subcarriers which was a difficult task at different fading conditions.

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