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Performance Analysis of MIMO FBMC Using Channel Equalization Techniques

Revathy R.L
Department of Electronics & Communication Engineering
Mar Baselios College of Engineering & Technology, Kerala, India

Anu Anna John,Assistant Professor
Department of Electronics & Communication Engineering
Mar Baselios College of Engineering & Technology, Kerala, India

ABSTRACT— A modified neural network based algorithm (NN) is used as an equalizer for MIMO-FBMC systems with QAM modulation .Each receiver has one NN equalizer per subchannel to estimate the channel which overcome the effect of ISI and ICI and improves signal detection.. Long training sequence affects the speed of communication so smaller length training sequence increase the rate. The channel equalization using neuro fuzzy can be used in MIMO FBMC. This equalizer recovers transmitted signal efficiently. The use of neuro-fuzzy equalizer decreases the training time and complexity of network .The proposed equalizer has computational simplicity, due to small size of the network, efficient extraction of information from a small number of training samples and it can achieve better performance.The performance of neuro fuzzy is compared with the MIMO FBMC using neural networks.

Keywords-NN, NF, MIMO, FBMC, ISI, Channel Equalizer, QAM

I. INTRODUCTION

Multicarrier systems achieve high rate in wireless communication. Digital filter banks have an applications in subband coding and multiple carrier data transmission. Multicarrier (MC) techniques combined with Multiple Input Multiple Output (MIMO) technology increase the throughput of the system.OFDM has a capability of converting the frequency selective channel into a frequency flat channel which have proved that it is one of the best multicarrier technique to MIMO channels. However,there is a bandwidth loss in OFDM due to cyclic prefix. Filter bank multicarrier (FBMC) modulation system, is highly bandwidth efficient method. The FMT based FBMC system offers same flexibility as OFDM in adopting MIMO techniques. MIMO techniques mainly highlighting the ISI and ICI mitigation methods through improved decoding techniques, equalization schemes and modified FBMC schemes [1].

1.1 MIMO-FBMC

FBMC is an alternative MC technique with a better spectral localization which overcomes the drawbacks of OFDM and it offers several advantages, lower spectral leakage, such as increased spectral efficiency through the removal of cyclic prefix ,reduced sensitivity to doppler effects. Recently various studies have been done on the various FBMC systems namely Filtered Multitone (FMT), Cosine Modulated Multitone (CMT), Staggered Modulated Multitone (SMT) or OFDM-OQAM and many improvements have been proposed for all the systems with respect to their applications to MIMO channels.

It offers the same flexibility of OFDM by using MIMO techniques. Therefore the channel can be approximated by a flat gain for each subcarrier band. However, FMT suffers a bandwidth loss because of there guard bands are employed. In CMT and SMT, the subcarrier overlap and offset QAM (OQAM) modulation is used, in which bandwidth is preserved.It has a drawback of inter carrier interference (ICI) and inter symbol interference (ISI) [1] .

II. NEURAL NETWORK

Artificial neural networks is a non linear information processing devices which built from interconnected by an elementary processing devices called neurons.An artificial neural networks are

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inspired from the biological nervous system.It consists of a large number of information processing unit called neurons to solve the problems.A neural network is parallel distributed processor that has a natural prospensity.In this the elements are called as neurons.The signal is transmitted by means of connection links. Each link consists of a weight which are multiplied with the incoming signal.The output signal is obtained after the activations to the net input.

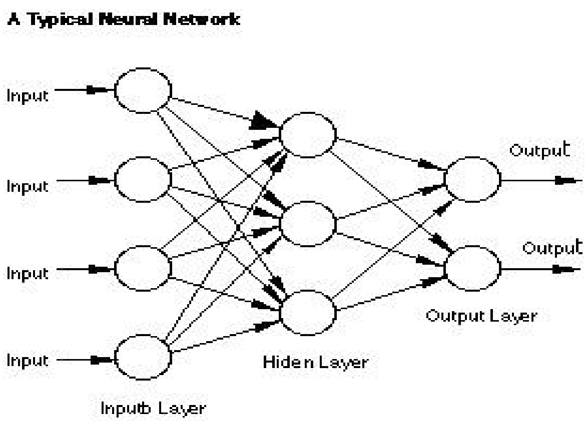

Fig 1.Artificial Neural Networks

An artificial neuron is characterized by:

1. Architecture(connection between neurons)
2. Training or learning(determining weights on the connection)

3.Activation function

The neurons with in a layer are fully interconnected or not interconnected. If two layers have interconnected weights then it have a hidden layer.There are different network Architecture: Feed Forward, feedback, fully interconnected net, competitive net etc.

The key terms used for artificial neural networks are weights ,bias, activation function and threshold Main benefit of neural networks is; they do not need a prior mathematical model. They use a learning algorithm to set the synaptic weight and bias values by using concept trial and error during the process of training. They don't need sequential processing and calculations, the neurons of NN work continuously and simultaneously. Feed forward networks known as multi layer perceptron (MLP) have been designed and analyzed for the purpose of estimation and compensation of channels effects [5]. Feed forward networks contain some hidden layers between input and x connections

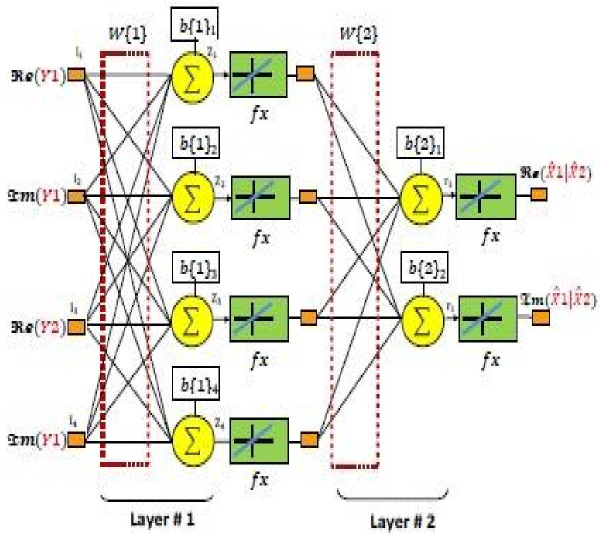

Fig 2 Architecture of NN (Same for both receivers)

The NN based estimator and compensator for simulation model shown in Figure 2 consists of two feed forward (MLP)networks NN1 & NN2, the architecture is same for both.During the training mode both networks identifies channel effects and update their weights and bias values.

During the operation mode NN1 is used to recovers x1 and NN2 is employed to recovers x2. The neural networks are designed such that they take four inputs at every instant of time (one for each input node). The four inputs are; Imaginary part ofY1, Real part of Y1, Imaginary part of Y2 and Real part ofY2. The input layer distributes inputs to four hidden nodes.Each input neuron is connected to each hidden neuron which results in 16 connections so the weight matrix of 1st layer is4x4 matrix and include 16 elements. Similarly every hidden node is connected to two output nodes which results in 8connections so the weight matrix of 2nd layer is 2x4 matrix and have 8 elements[1]

A. TRAINING MODE

Training is a method during which the weights and bias values of a network are updated. The proposed system calculates the estimate of channel in terms of neural network's weights and bias values. Backpropagation is implemented for the purpose of training. Neural networks are given some input values and corresponding target values for the output, and then the training algorithm compute the weights and bias values of the particular network

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with the help of those inputs and provided target values[1]

B. OPERATION MODE

During the operation mode received data sequences are provided at the input of networks, passed through them and straight calculations are made to compute the estimate of transmitted data sequences[1].

C. BACK PROPAGATION NETWORK

Back propagation is a method for training multi layer artificial neural network.It is multilayer forward network using gradient descent based delta learning rule,commonly known as back propagation errors.

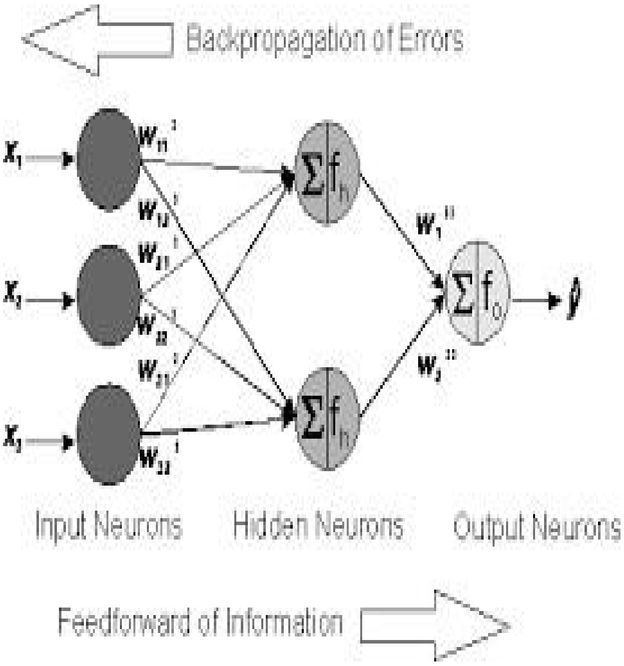

Fig 3 Back Propagation

The weights can be changed in a feed forward network using back propagation algorithm. The supervised learning method is used for training.using the gradient descent method it minimizes the total squared error .The output units and the hidden units have bias.The bias acts like weights on connection from inputs.The neural network has one input layer,one hidden layer and one output layer.The input layer is connected to hidden layer by means of weights and the hidden layer is connected to output layer by means of interconnection of weights.During back propagation the signals are going in reverse direction.The increase no. of hidden layers cause computational complexity of the network.

III.NEURO FUZZY INFERENCE SYSTEM

The use of fuzzy technology is one of the effective wat for the development of adaptive equalizers for non linear channels.The fuzzy equalizer is proposed for adaptive equalization. Human experts determine the fuzzy rules using input output datapairs of the channel [7]. The filters for the non linear channel is constructed using the rules. The RLS and LMS algorithms are applied to change parameters of the membership function of rules and develop equalizers. The fuzzy adaptive filters are developed using linguistic and numerical informations. The adaptation speed is improved by this approach[7].

In some case the construction of fuzzy rules for equalizers is difficult.The neuro fuzzy technology allows to use small no. of parameter easy and fast train equalizers. The Fuzzy inference system (FIS) is based on fuzzy if-then rules, fuzzy set theory and fuzzy reasoning. The key component in FIS is the framing of the fuzzy if-then rules. FIS is a very popular technique and it is applied in different fields like system identification ,data classification, expert system, time series analysis, pattern classification, decision making, robotics, automatic control etc.

The basic structure of a fuzzy inference system consists of three principal components viz a rule base comprising of the selected fuzzy rules, a database defining the membership functions of the fuzzy rules, and a reasoning mechanism which performs a fuzzy reasoning inference with respect to the rules so as to derive a reasonable output or conclusion.

A. ADAPTIVE NETWORK BASED FUZZY INFERENCE SYSTEM

A neuro-fuzzy technique called Adaptive network based fuzzy inference system (ANFIS) is used as an prime tool. Adaptive network based fuzzy inference system (ANFIS) is a neuro fuzzy technique which is the combination of the neural network and the fuzzy inference system. The parameters in ANFIS can be estimated by both the Sugeno and Tsukamoto fuzzy models which are represented by the ANFIS architecture. The ANFIS model resembles the Radial basis function network (RBFN) functionally.It comprises of a hybrid system of fuzzy logic and neural network technique. The fuzzy logic takes into account the uncertainity an dimprecision of the system[9].

The rules are extracted from the input output data of the system initial fuzzy model along with its input variables are derived. Using the neural network the rules are fine tune to form the initial fuzzy model to produce the final ANFIS model of the system. In this proposed work ANFIS is used as the backbone for the identification of real world systems[9]. In ANFIS sugeno type fuzzy inference system is used. The output of each rule is the linear combination of input variable plus a constant term.The final output is the weighted average of every single output rule's.for example

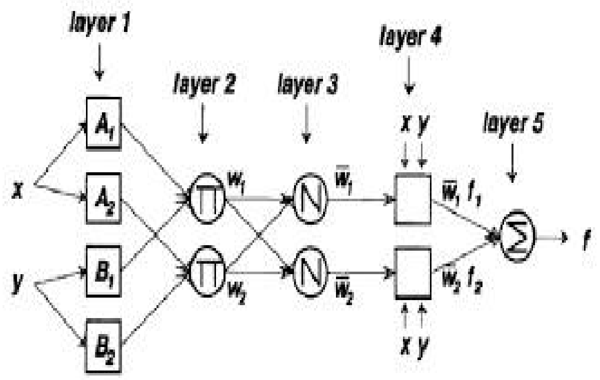

Fig 4 ANFIS

Rule 1:if x is A1 and y is B1,then f1=p1x+q1y+r1

Rule 2:if x is A2 and y is B2,then f2=p2x+q2y+r2

The nueral network contain 5 layer

(1) Layer 0, input layer,has n nodes,n is the numberof inputs
(2) Layer 1,the fuzzification layer in which each node represent a membership value to a linguistic term as Gaussian function
(3) Layer 2,it provides strength of the rule by means of multiplication operator
(4) Layer 3,it is the normalization layer which normalizes the strengthof all rules thereP^n nodes
(5) Layer 4,is a layer of adaptive nodes
(6) Layer 5,it is the output layer whose function is the summation of net outputs of the nodes in layer 4

The performance of ANFIS is determine after the training is complete

The SNR Vs BER for Neural network is plotted for 16-QAM

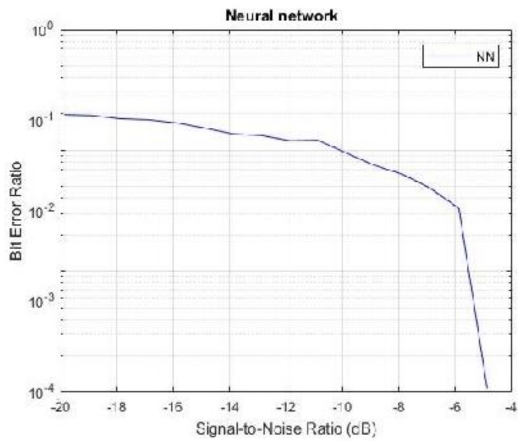

Fig 5 SNR Vs BER for Neural Network Equalizer

The SNR Vs BER for ANFIS is plotted for 10 epochs and for 16 QAM is plotted

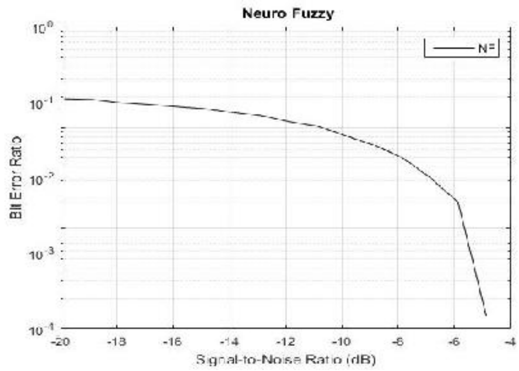

Fig 6 SNR Vs BER For Neuro Fuzzy Equalizer

The results of Neural network is compared with the Neuro Fuzzy Equalizer

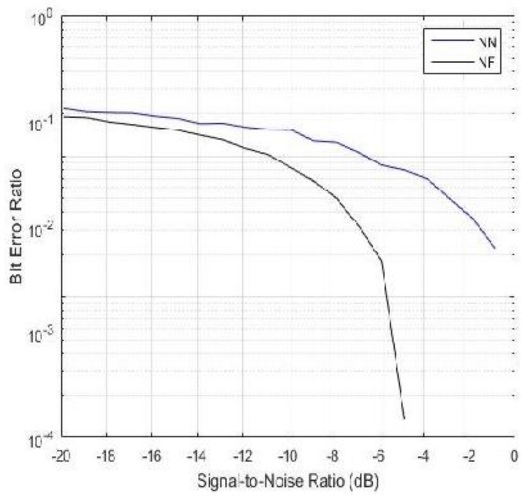

Fig 7. SNR Vs BER For Neural Network And Neuro Fuzzy Equalizer

The time consumption for Neural network is more than Neuro Fuzzy Equalizer

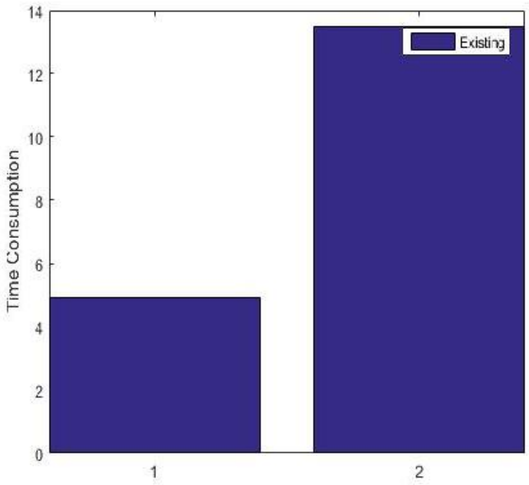

Fig 8. Time consumption for NN and NF

IV SIMULATION RESULTS

The random binary input signals are transmitted through communication channel. These signals are corrupted by additive noise n(k). These signals are given to the equalizer. The problem of the channel equalization is to estimate the input signals.The neuro-fuzzy network structure and its training algorithm is used to for equalization. The inputs of neuro-fuzzy equalizer are channel output signals.The output of neural network is the recovered transmitted sequence of signal. During equalizer design the sequence of transmitted signals are given to the channel input.

The additive noise is added to the transmitted signal. In the equalizer-using target transmitted signal the deviation from the current network output is determined. This error is used to adjust equalizer parameter. Training is continued until the value oferror for all training sequence of signals would be minimum.The channel equalization using MIMO-FBMC is done with Neural network and Neuro Fuzzy equalizers.The SNR vs BER for both is compared for NN and NF. The BER vs SNR for neuro fuzzy is compared with neural network from the figure 6 the neuro fuzzy gives better performance than neural network.In neural network there is computational complexity training time is high and its solved by neuro fuzzy network

V.CONCLUSION

The channel equalization technique based on neural network equalizer,neural-fuzzy equalizer that provides the channel estimation for MIMO-FBMC communication models and the results have been examined The development of neural network equalizer,neural-fuzzy equalizer for equalization channel distortion is carried out. The operation principle and learning algorithm of neuro-fuzzy network and neural network are represented. The construction of neuro-fuzzy equalizer and neural network equalizer is carried out for the channel in presence of additive distortion.The obtained results of simulation of neuro-fuzzy equalizer, neural network equalizer are given.

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