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An adaptive algorithm for minimization of phase noise in OFDM system over multipath fading channel

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Abstract: In the performance of Orthogonal Frequency division multiplexing (OFDM) system, Phase noise causes significant degradation.RBF (Radial Basis Function) Network is applied for OFDM system to estimate the amplitude and the angle of the frequency domain channel coefficients having two parts of network was improved. In this paper, RBF (Radial Basis Function) Network is proposed for minimizing phase noise in OFDM system based on LMS (Least Mean Square) algorithm and MSE (Mean Square Error) algorithm, so that the system will improve.

Keywords: Orthogonal Frequency division multiplexing (OFDM) system, Phase noise, signals to noise ratio (SNR), RBF(Radial Basis Function) Network.

I. INTRODUCTION

OFDM is a multi-carrier modulation technique with densely spaced sub-carriers which has a lot of useful properties such as delay-spread tolerance and spectrum efficiency that encourage their use in broadband communications. OFDM is a multi-channel modulation system employing Frequency Division Multiplexing (FDM) of orthogonal sub-carriers, each modulating a low bit-rate digital stream. OFDM is similar to conventional frequency-division multiplexing (FDM). The difference lies in the way in which the signals are modulated and demodulated. The OFDM receiver is presented to assess the impact of the phase noise on the decision variables at the receiver. It is then shown that the effect of phase noise on the decision variables is composed of two components: a common component which affects all data symbols equally and as such causes a sometimes visible rotation of the signal constellation, and a second component which is more like Gaussian noise and thus affects the received data points in a somewhat random manner.

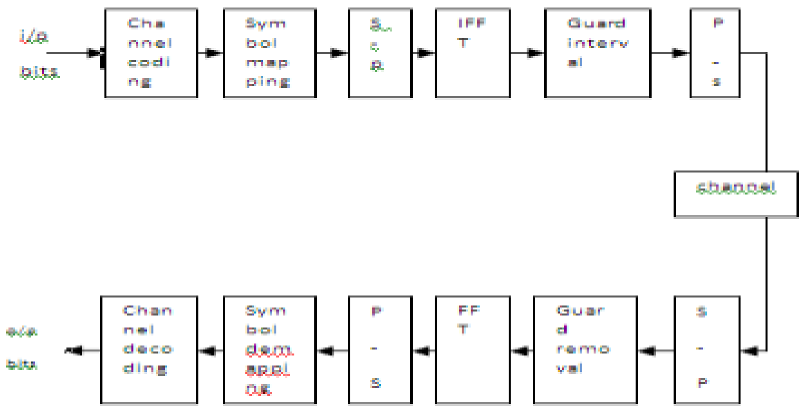
In wireless communications, fading is deviation of the attenuation affecting a signal over certain propagation media. A fading channel is a communication channel comprising fading. Fading may either be due to multipath propagation, referred to as multipath induced fading, or due to shadowing from obstacles affecting the wave propagation, sometimes referred to as shadow fading. Multipath means (Communication Arts / Broadcasting) relating to television or radio signals that travel by more than one route from a transmitter and arrive at slightly different times, causing ghost images or audio distortion. In wireless communication, multipath is the propagation phenomenon that results on radio signals reaching antenna by two or more paths Causes of multipath include atmospheric ducting , ionosphere reflection and refraction and terrestrial object such as mountains , buildings or vehicles .

The effects of multipath include constructive and destructive interference and phase shifting of the signal which results in fading of the signal called multipath fading .Small scale fading is usually divided into fading based on multipath time delay spread and that based on Doppler spread.

A neural network is a system composed of many simple processing elements operating in parallel whose function is determined by network structure, connection strengths, and the processing performed at computing elements or nodes. A basic component of many neural nets, both natural and artificial, is the feed forward network. Radial basis function (RBF) networks can require more neurons than standard feed forward back propagation networks, but often they can be designed in a fraction of the time, it takes to train standard feed forward networks .Radial basis function (RBF) networks have the advantages of an easy design, simple structure, good generalization, high tolerance of input noise and rapid training process.

The paper is organised as follows. In section II, the system model and principal concept of OFDM system are presented. In section III, multipath fading channel and RBF network are structured. The simulation results are given in section IV and finally, section V concludes the paper.

II. SYSTEM MODEL



. Fig.1: Block diagram of general OFDM system

A general block diagram of OFDM system is shown in Fig.1. The first step in deciding on the coding and modulation techniques is determining the number of bits carried by an OFDM symbol. Then, a suitable combination of modulation and coding techniques can be selected to fit the input data rate into the OFDM symbols and, at the same time, satisfying the bit-error rate requirements.So that the input bits are transmitted with the channel coding which are then mapped using baseband modulation scheme such as QAM.Then the serial-to-parallel conversion is applied to baseband modulated signals.After that,the orthogonality allows for efficient modulator implementation using IFFT algorithm and then guard time results in an SNR loss in an,since it carries no information for the delay spread of multipath channel.At the receiving end,the guard interval is removed and then is applied to FFT algorithm to demodulated the symbol rate and channels.

Mathematical Description:

If N subcarriers are used and each subcarrier is modulated using M alternative symbols ,the OFDM symbol alphabet consist of M^N combined symbols.
The low pass equivalent OFDM signal is expressed as:

$$V(t) = \sum_{k=0}^{N-1} Xk\, e_T^{j2\pi ft}, \quad 0 \leq t \leq T,$$

Where ,$\{x_k\}$ are the data symbols,N is the number of subcarriers and T is the OFDM symbol time .The subcarreier spacing of 1/T makes them orthogonal over each symbol period,this property is expressed as:

$$\frac{1}{T}\int_0^T \left(e_T^{j2\pi k1t}\right) * \left(e_T^{2\pi k2t}\right)dt$$

$$= \frac{1}{T}\int_0^T e_T^{j2\pi\,(k2-k1)t}\, dt = \delta k1k2$$

Where (.)* denotes the complex conjugate operator and δ is the Kronecker delta.
To avoid intersymbol interference in multipath fading channels,a guard interval of length T_g is inserted prior to the OFDM system block.During this interval,a cyclic prefix is transmitted such that the signal in the interval $-T_g \leq t \leq 0$ equals the signal in the interval $(T - T_g) \leq t \leq T$. The OFDM signal with cyclic prefix is as :

$$V(t) = \sum_{k=0}^{N-1} Xk\, e_T^{j2\pi ft}, \quad -T_g \leq t \leq T$$

The low-pass signal above can be either real or complex valued.Real valued low pass equivalent signals are typically transmitted at baseband wireline applications such as DSL use this approach.For wireless applications,the low pass signal is typically complex valued in which case, the transmitted signal is up converted to a carrier frequency f_c.
In general, the transmitted can be represented as
:
$s(t) = \{\ v(t)e^{j2\pi fct}\ \}$

$$\sum_{k=0}^{N-1} Xk\ \cos\ \left(2\pi\left[fc + \frac{k}{T}\right]t + \arg[Xk]\right)$$

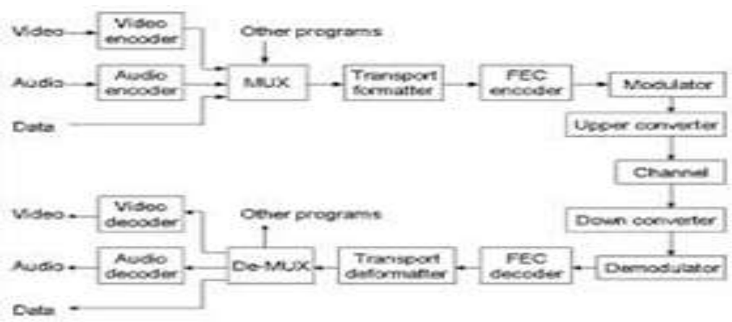
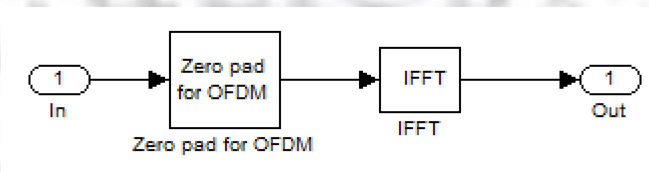


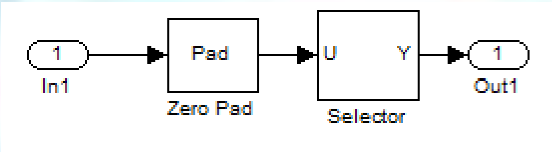
Fig. 2: Block diagram of Digital Video Broadcast Terrestrial

DVBT stands for transmitting bits from one (or a few) ground based transmitters to very many receivers i.e. they are broadcast standards. They are designed to have the capacity to transmit live digital television. Basically it is widely used digital television standard in use around the globe for terrestrial television transmission. It enables a more efficient use of the available radio frequency spectrum than analog transmission.

OFDM TRANSMITER:



ZERO PAD FOR OFDM:

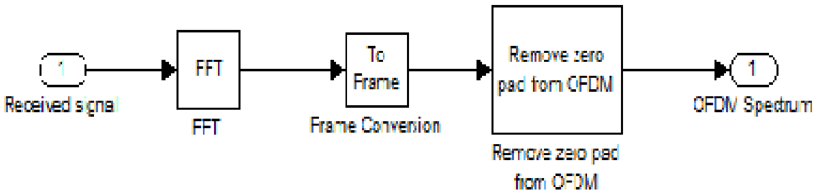


ZERO PAD:

Append or pretend a constant value to the input along the specified dimensions. Truncation occurs when the specified output dimensions are shorter than the corresponding input dimensions.

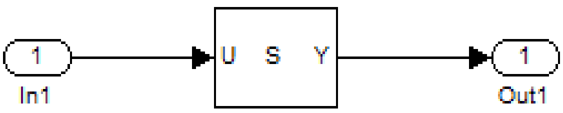
AWGN: Add white Gaussian noise to the input signal. The input signal can be real or complex. This block supports multichannel processing. When using either of the variance modes with complex inputs, the variance values are equally divided among the real and imaginary components of the input signal.

OFDMRECEIVER:



FFT: Compute the fast Fourier transform (FFT) across the first dimension of the input.

REMOVE ZERO PAD FROM OFDM:



Select or reorder specified elements of a multidimensional input signal. The index to each element is identified from an input port or this dialog. You can choose the indexing method for each dimension by using the "Index Option" parameter.

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III. STRUCTURAL MODELING

A. Multipath Fading Channel

Multipath Fading is mitigated in two ways.
Flat fading: This form of multipath fading affects all the frequencies across a given channel either equally or almost equally. When flat multipath fading is experienced, the signal will just change in amplitude, rising and falling over a period of time, or with movement from one position to another. **Selective fading:** Selective fading occurs when the multipath fading affects different frequencies across the channel to different degrees. It will mean that the phases and amplitudes of the signal will vary across the channel.

B. RBF (Radial Bsis Function)Network

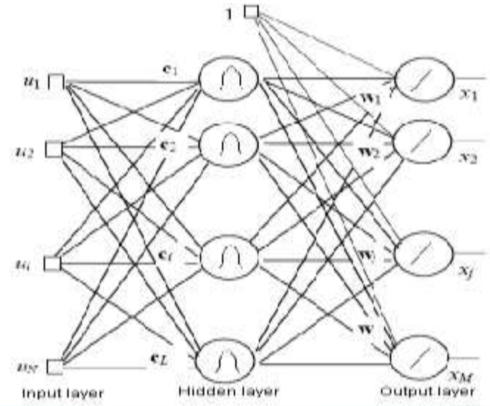

Fig. 3: Structure of standard RBF Network

The structure of RBF Network is shown in Fig.3The input layer is made up of source nodes (sensory units) whose number is equal to the dimension p of the input vector u.The second layer is the hidden layer which is composed of nonlinear units that are connected directly to all of the nodes in the input layer. It is of high enough dimension, which serves a different purpose from that in a multilayer perception. The third layer is output layer which has transformation from the input space to the hidden unit space is nonlinear, whereas the transformation to the hidden unit space to the output space is linear.

The j^{th} output is computed as:

$X_j = f_j(u) = W_{0j} + \sum_{i-1}^{L} Wijhi$, j = 1, 2….M

Mathematical Model :
In summary, the mathematical model of the RBF network can be expressed as:
$x = f(u)$, $f: RN \rightarrow R^M$
$Xj = f_j(u) = w_{0j} + \sum_{i-1}^{L} wij\, G(\|u - ci\|)$, j=1, 2, M
where ‖·‖ is the the Euclidean distance between u and ci.

IV. SIMULATION RESULTS

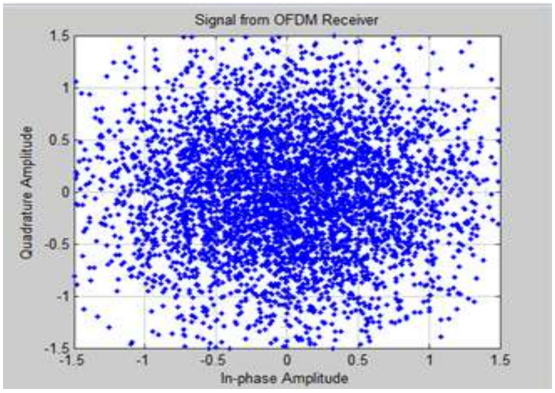

Fig.4 DVBT system with phase noise for AWGN channel

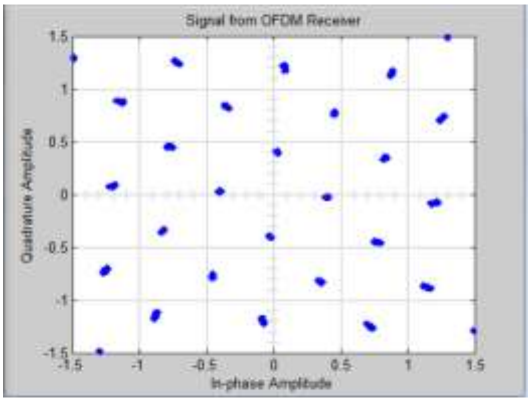

Fig.5 DVBT system with phase noise for Ricean channel

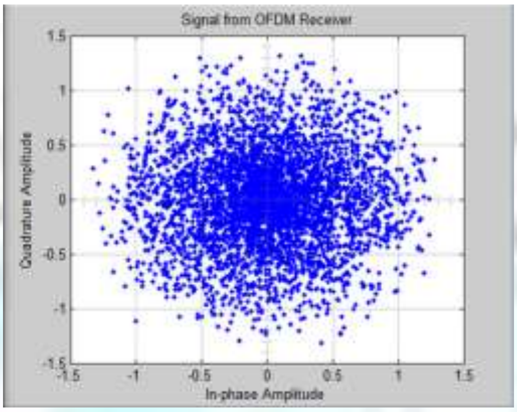

Fig. 6 DVBT system with phase noise for Rayleigh channel

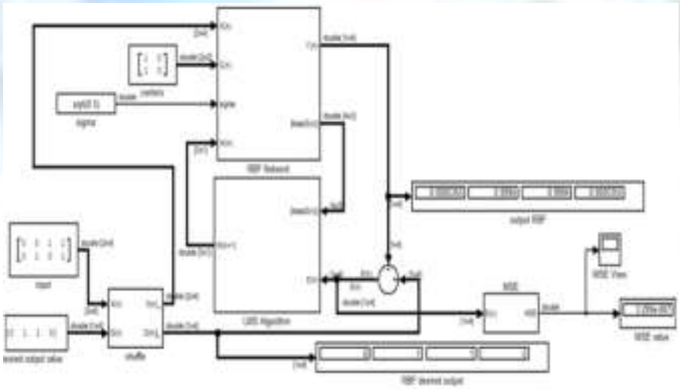

Fig.7 RBF network with LMS algorithm

In this section, the simulation results proposed for minimization of phase noise in OFDM system.Fig.4 shows the DVBT system with phase noise for AWGN channel concludes the signal constellations distributed between the quadrature and phase quadrature modulation.

Fig.5 shows DVBT system with phase noise for Ricean channel concludes the signal constellations distributed in all four quadrant but in a less quantity. Riceaan fading is a stochastic model for radio propagation anomaly caused by partial cancellation of a radio signal by itself — the signal arrives at the receiver by several different paths (hence exhibiting multipath interference), and at least one of the paths is changing (lengthening or shortening). Rician fading occurs when one of the paths, typically a line of sight signal, is much stronger than the others. In Rician fading, the amplitude gain is characterized by a Rician distribution.

Fig.6 shows the DVBT system with phase noise for Rayleigh channel fixed at a point and signal constellations distributed in all quadrants. Rayleigh fading models assume that the magnitude of a signal that has passed through such a transmission medium (also called a communications channel) will vary randomly, or fade, according to a Rayleigh distribution — the radial component of the sum of two uncorrelated Gaussian random variables. Rayleigh fading channel itself can be modelled by generating the real and imaginary parts of a complex number according to independent normal Gaussian variables.

The proposed RBF network which is a soft computing technique used for minimization of phase noise based on LMS algorithm and MSE algorithm.LMS(Least Mean Square) algorithms are a class of adaptive filter used to mimic a desired filter by finding the filter coefficients that relate to producing the least mean squares of the error signal.MSE (Mean Square Error) of an estimator is one of many ways to quantify the differnce between values implied by an estimator and the true values of the quantity being estimated.Fig.7 shows the RBF network based on LMS algorithm and MSE algorithm. Consider 2 inputs which are shuffled and transmitted to the RBF network which are then calculated with the MSE algorithm to get desired output.

Table 1

Modulation	Code rate	Gaussian channel [dB]	Ricean channel [dB]	Rayleigh channel [dB]
QPSK	1/2	3.1	3.6	5.4
	2/3	4.9	5.7	8.4
	3/4	5.9	6.8	10.7
	5/6	6.9	8.0	13.1
	7/8	7.7	8.7	16.3
16-QAM	1/2	8.8	9.6	11.2
	2/3	11.1	11.6	14.2
	3/4	12.5	13.0	16.7
	5/6	13.5	14.4	19.3
	7/8	13.9	15.0	22.8
64-QAM	1/2	14.4	14.7	16.0
	2/3	16.5	17.1	19.3
	3/4	18.0	18.6	21.7
	5/6	19.3	20.0	25.3
	7/8	20.1	21.0	27.9

In Table 1, the minimum C/N ratio required for quasi error free reception is shown. The values are based on simulations of the system behavior and were computed on the assumption that a perfect correction of the channel frequency response has taken place . The Gaussian channel is characterized by one direct signal path from transmitter to receiver. The only impairment present is additive white Gaussian noise (AWGN). In order to describe the impairment caused by echoes the Ricean channel is defined, which takes into account the effect of multipath signals in addition to AWGN. A dominant direct signal path is present. A transmission channel with echoes of more or less equal significance and without any direct signal path is called Rayleigh channel. It can be seen that the required C/N ratio increases with the complexity of the transmission channel.

V. CONCLUSION

In the proposed paper , RBF (Radial Basis Function) network which is one of the soft computing technique used for minimizing the phase noise in OFDM system with respect to LMS algorithm and MSE algorithm.It shows the performance of DVBT model with phase noise for AWGN channel,Rayleigh channel and Racian channel.By comparing these three channels,the AWGN channel shows the better performance for the DVBT model.It also concludes that the RBF (Radial Basis Function) network is simple technique to minimize phase noise from the system, so that the system is improved.

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