Minimizing IQ Imbalance for OFDM System in Fast Fading Channels

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Abstract: Minimizing IQ Imbalance for OFDM System in Fast Fading Channels system is proposed in this system soft computing technique is used to minimize major weakness of OFDM that is IQ imbalance over fast fading channel based on least mean square and Mean square error algorithms. IQ imbalance causes significant degradation in the performance of Orthogonal Frequency Division Multiplexing (OFDM) system. IQ imbalance effects the SNR consequently limits the bit error rate (BER) and data rate. The performance of the OFDM system is evaluated in AWGN wireless channel model.

Keywords: OFDM, IQ, BER, SNR.

I. INTRODUCTION

OFDM has been widely esteemed as an effective tech unique for mitigating effects of inter-symbol interference in a frequency selective fading channel This technique has been adopted for several wireless systems such as IEEE802.11a and DVB-T . For increasing data rate, it is necessary to apply high-order modulation to OFDM which causes non-idealities. These non-idealities of an analog front-end cannot be ignored. IQ imbalance is one of the known non-idealities of the analog front-end. It has been presented that IQ imbalance causes crosstalk between symmetrical subcarrier pairs for OFDM.

In order to compensate crosstalk between subcarriers, a method which uses pilot signals inserted in frequency domain has been proposed. In this method, to compensate IQ imbalance effect, the crosstalk of all subcarriers using pilot signals has been estimated. However, it is necessary for frequency spacing's between pilot signals to be close enough in comparison with channel coherent band- width because crosstalk estimated by pilot signals depends on channel response of each subcarrier. A method which is regardless of frequency spacing's of pilot signals is also proposed. In this method, IQ imbalance parameters using pilot signals is estimated and then compensate the effect of IQ imbalance based on estimated IQ imbalance parameter. Soft-Computing involves various techniques having many fields that fall under various categories in Computational Intelligence. Soft-Computing has three main branches: Fuzzy Logic, genetic algorithm, and Neural Networks. Fuzzy logic consists of Soft Computing technique widely used for analyzing complex systems, especially where the data structure is characterized by several linguistic parameters.

A neural network system consists of processing elements operating in parallel and its function is determined by connection strengths, network structure, and at computing elements and nodes. Neural nets, consist of natural and artificial and it is the feed forward network. A radial basis function (RBF) network is a software system that can classify data and make predictions. RBF networks are similar to neural networks, but are actually quite different. Radial basis function networks can require more neurons than standard feed forward back propagation networks. Radial basis function (RBF) networks is easy to design, simple in structure, high tolerance of input noise and rapid training process. An RBF network accepts more than one numeric input and generates more than one numeric outputs.

II. PROPOSED SYSTEM

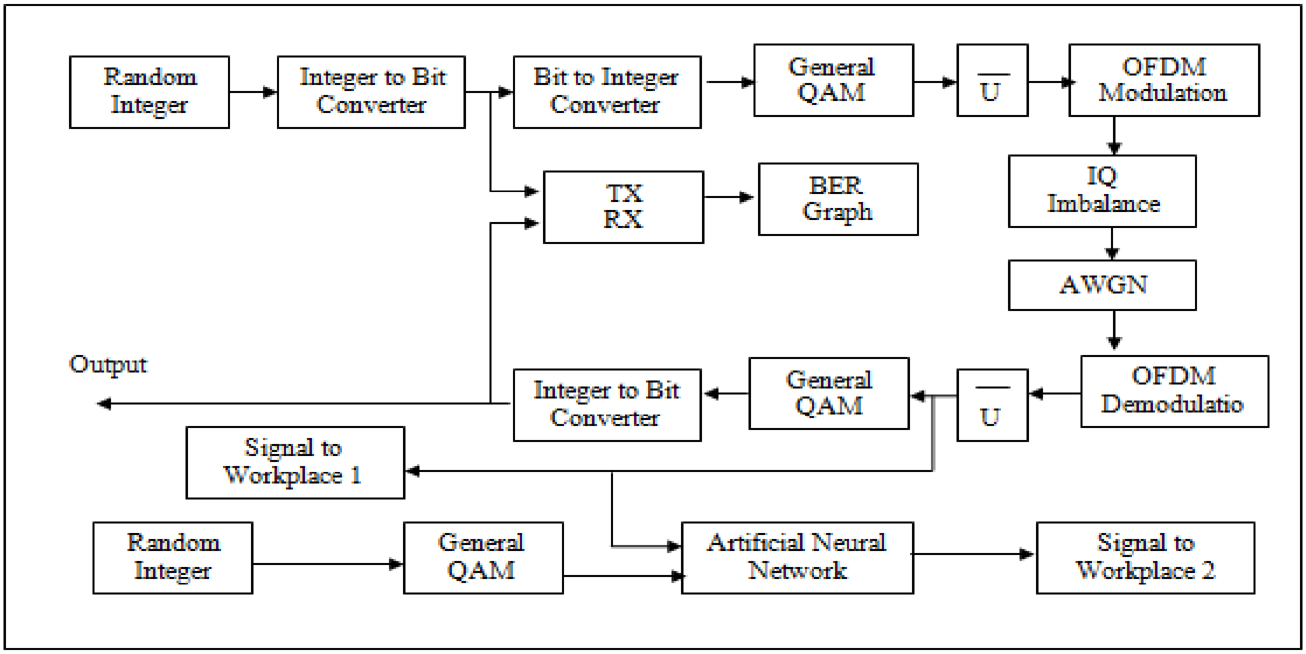

Figure 1: Block Diagram of proposed System

A. Mathematical Model for OFDM System

If N subcarriers are used and each subcarrier is modulated using M alternative symbols, the OFDM symbol alphabet consist of MN 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 subcarrier 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 inter symbol interference in multipath fading channels, a guard interval of length Tg is inserted prior to the OFDM system block. During this interval, a cyclic prefix is transmitted such that the signal in the interval $-Tg \leq t \leq 0$ equals the signal in the interval $(T - Tg) \leq t \leq T$. 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 wire line 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 fc . In general, the transmitted can be represented as:

$$s(t) = \{ v(t) e^{j2\pi fct} \}$$

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

In order to do a Monte carlo simulation of an OFDM system, required amount of channel noise has to be generated that is representative of required Eb/N0 . In Matlab it is easier to generate a Gaussian noise with zero mean and unit variance . The generated zero-mean-unit-variance noise has to be scaled accordingly to represent the required Eb/N0 or Es/N0. If we have Es/N0, the required noise can be generated from zero-mean-unit-variance-noise by,

$$\text{Required noise} = 10^{\frac{-Es}{N0}*\frac{1}{20}} * \text{noise}$$

Since the OFDM system transmits and received the data in symbols, it is appropriate/easier to generate required noise based on Es/N0 instead of Eb/N0.

simple BPSK system, bit energy and symbol energy are same.

So Eb/N0 and Es/N0 are same for a BPSK system. But for a OFDM BPSK system, they are not the same. This is because, each OFDM symbol contains additional overhead in both time domain and frequency domain. In the time domain, the cyclic prefix is an additional overhead added to each OFDM symbol that is being transmitted. In the frequency domain, not all the subcarriers are utilized for transmitted the actual data bits, rather a few subcarriers are unused and are reserved as guard bands. [21,22]

B. **Simple DVBT Model for AWGN Channel**

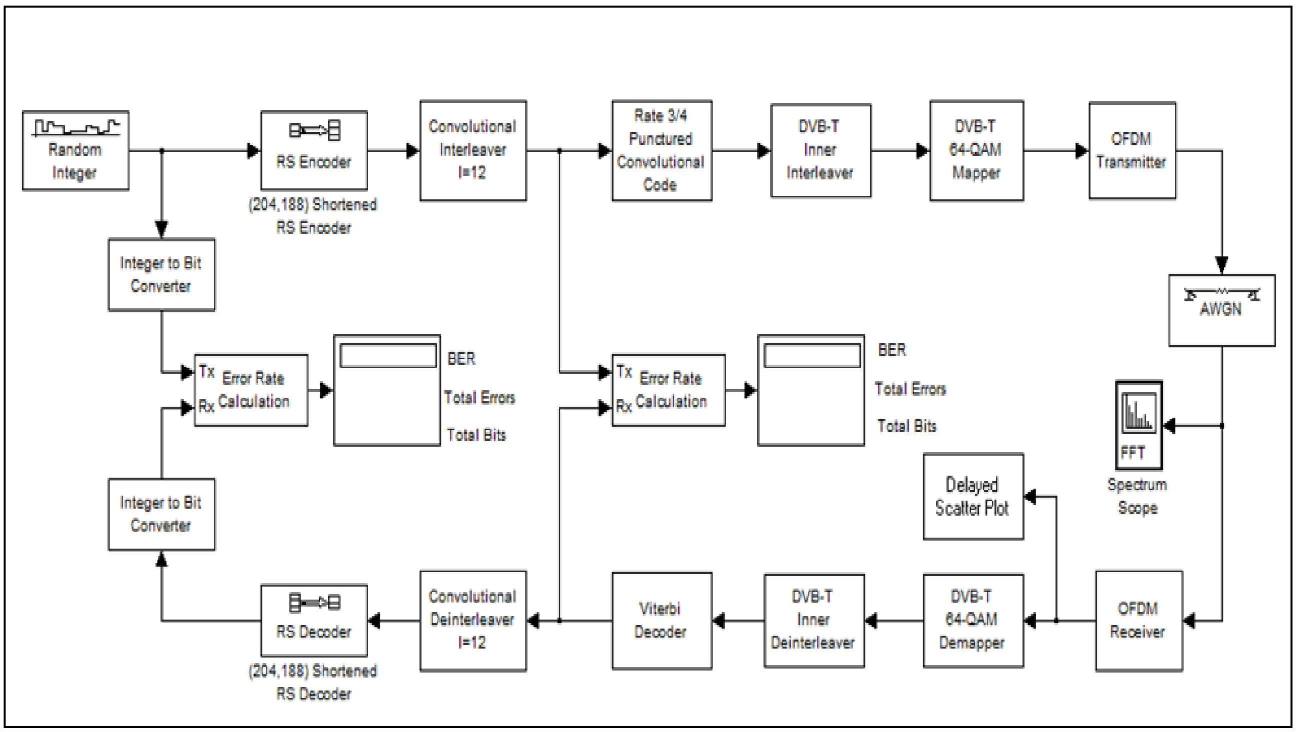

Figure 2: Block Diagram of Simple DVBT model for AWGN [23]

Using subsystem based implementation Soft decisions are computed. In-phase and quadrature after appropriately scaling the received signal, phase signal components are extracted and then they are shifted to obtain soft decisions for various bits. A 64 -QAM makes soft decisions and produces a set of six real numbers for To convert given Eb/N0 to Es/N0 for an OFDM system , normally for a

each complex number in its input. These six numbers represent soft decisions on the real and imaginary components' first bit, second bit, and third bit. The Viterbi Decoder subsystem interprets the soft-decision numbers and uses them to decode the punctured convolution code properly.

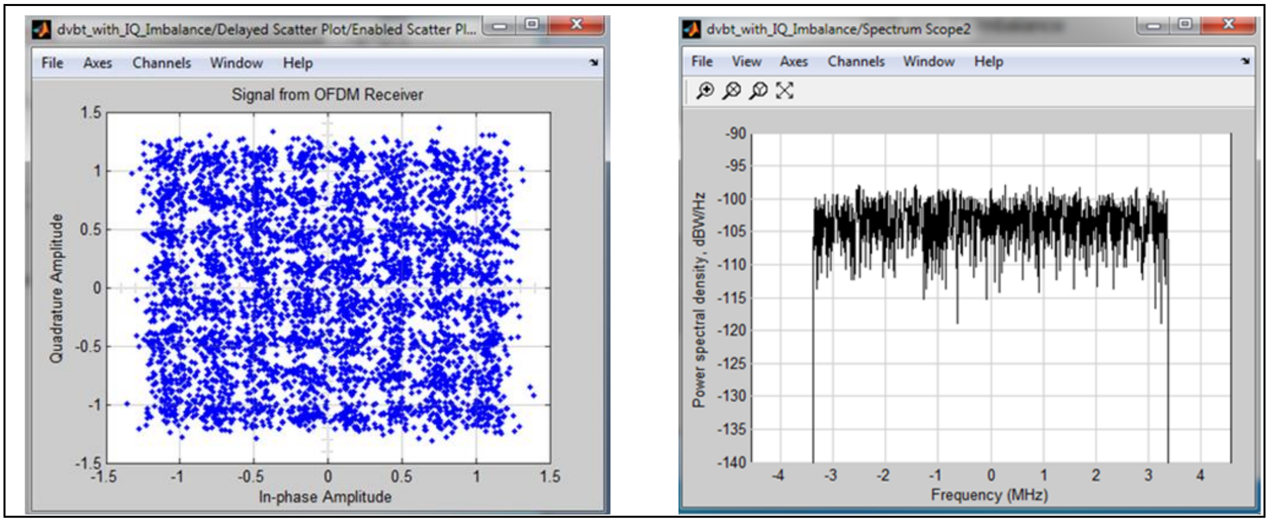

Figure 3: Simulation result for Simple DVBT model for AWGN channel

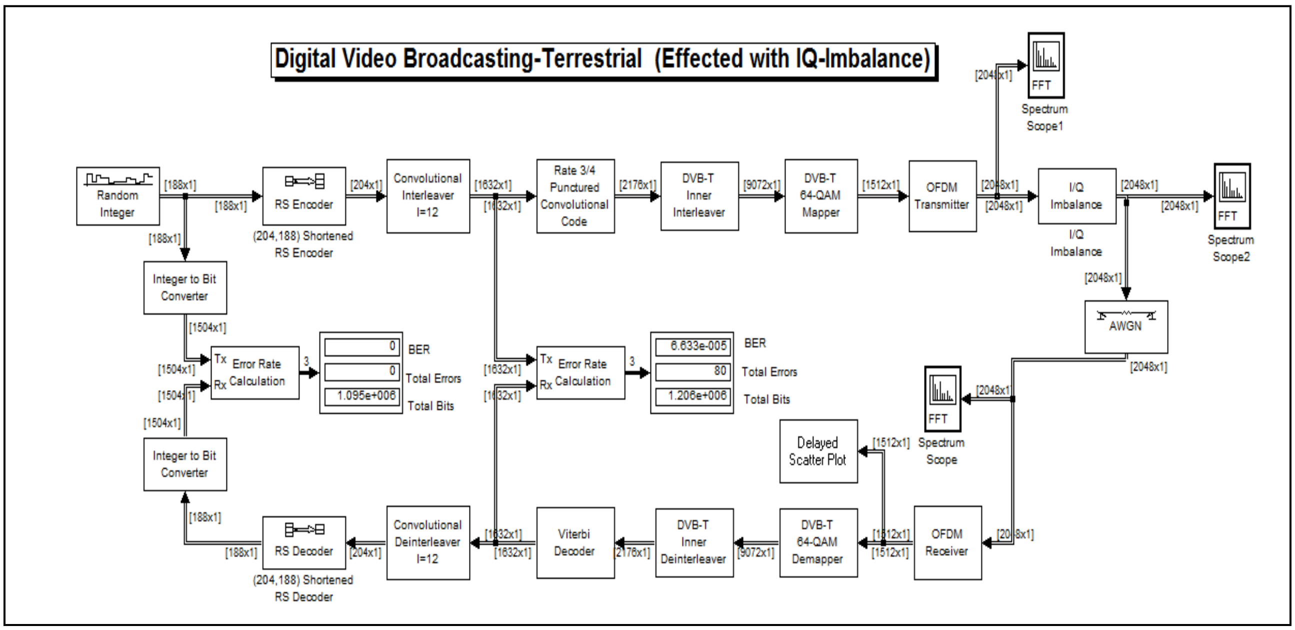

Figure 4: Block Diagram of DVBT model for AWGN channel with IQ imbalance [24]

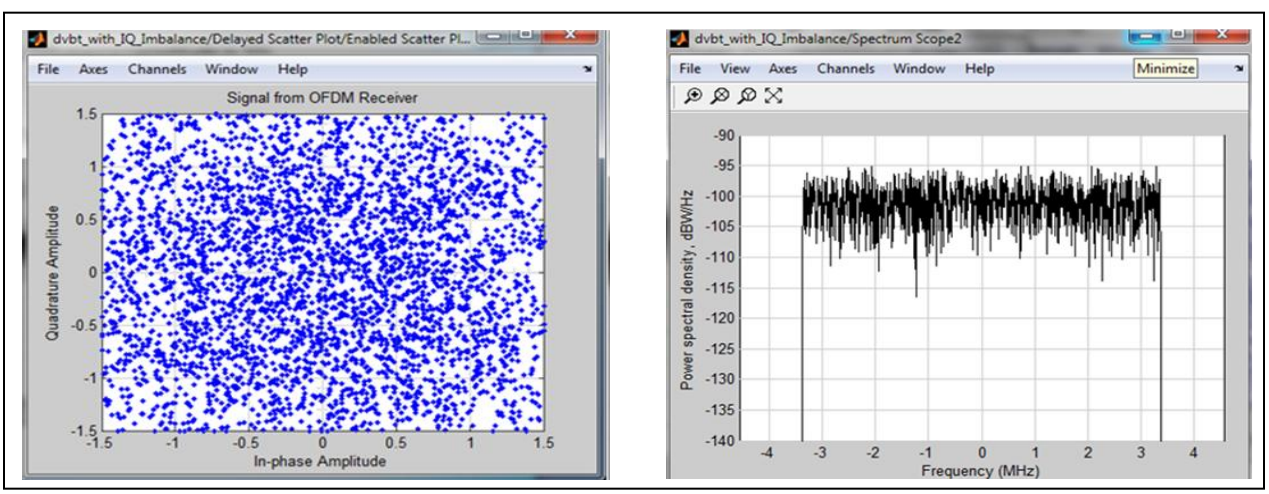

Figure 5: Simulation result for DVBT model for AWGN channel with IQ imbalance

III. CONCLUSION

The proposed system Minimizing IQ Imbalance for OFDM System in Fast Fading Channels system ia an intelligent structure to reduce IQ imbalance using Artificial Neura Network in OFDM System. The Neural Network aim to pursue and comprehend significant data with which it is trained the Nural Network helps to arrive at better solution which result in reduction in IQ imbalance.

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