

Comparison of Various Channel Equalization Techniques in OFDM System using different Digital Modulations

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Abstract

The nature of future wireless applications requires high data rates and for this OFDM technique is used. OFDM stands for orthogonal frequency division multiplexing and is a type of multi-carrier transmission where all the subcarriers are orthogonal to each other. At high data rates, the channel distortion to the data is very important and it is somewhat impossible to recover the transmitted data with a simple receiver. So a complex receiver structure is needed which uses computationally expensive equalization and channel estimation algorithms to estimate the channel. These estimations can be used within the received data to recover the originally transmitted data. OFDM can simplify the equalization problem by changing the frequency-selective channel into a flat channel. The radio channels in mobile radio systems are usually multipath fading channels that results in intersymbol interference (ISI) in the received signal. To remove ISI from the signal, many kind of equalizers can be used. The need for equalizers arises from the fact that the channel has amplitude and phase dispersion which results in the interference of the transmitted signals with one another which is known as ISI. So, to solve this problem equalizers are designed. Equalizer is intend to work in such a way that Bit Error Rate (BER) should be low and Signal-to-Noise Ratio (SNR) should be high. An equalizer within a receiver compensates for the average range of expected channel amplitude and delay characteristics. This paper deals with the various equalization techniques (LMS, RLS and CMA) used for OFDM system. A comparative analysis of different equalization technique in terms of BER is done using MATLAB Simulink.

Keywords: wireless, intersymbol interference (ISI), equalizer, bit error rate, signal to noise ratio (SNR), matlab, multipath

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1. Introduction

Multimedia services like audio, video and text requires very high data rate and for this OFDM system is used. In digital communications, the equalizer's purpose is to reduce intersymbol interference (ISI) to allow recovery of the transmit symbols. The equalizer is the most expensive component of a data demodulator and it can consume over 80% of the total computations needed to demodulate a given signal [1].

The digital transmission system provides higher reliability in noisy environment in comparison to the analog transmission. But sometimes the digital information, i.e. the transmitted pulses is smeared out so that pulses corresponding to different symbols are not separable, and this phenomenon is known as inter-symbol interference (ISI) [1]. As the channel has amplitude and phase dispersion that results in the interference of the transmitted signals with one another. So, in order to solve this problem equalizers are designed. Equalizer is meant to work in such a way that Bit Error Rate (BER) should be low and Signal-to-Noise Ratio (SNR) should be high [9]. Equalizer gives the inverse of channel to the received signal and combination of channel and equalizer gives a flat frequency response and linear phase. The noise performance of static equalizer is not very good. Most of the times the transmission system's transfer functions are not known. Also, the channel's impulse response may vary with time. This results in difficulty in designing the equalizers. So, mostly preferred scheme is adaptive equalizers. An adaptive equalizer is an equalization filter that automatically adapts to time-varying properties of the communication channel. It is a filter that self-adjusts its transfer function according to an optimizing algorithm. Adaptive algorithms are used in the fields of biomedical, image processing, communication signal processing and many more [2]. Figure 1

shows the block diagram of an adaptive equalizer, where Random Noise Generator (1) provides the input signal and Random Noise Generator (2) provides additive white noise to corrupt the channel output. The adaptive equalizer performs the task of correcting the distortions produced by channel in presence of additive white noise.

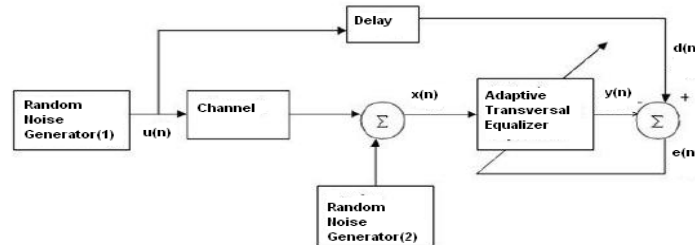


Figure 1. Block Diagram of Adaptive Equalizer

The equalizers are divided into two groups linear and non-linear, based on their implementation and performance. Linear equalizers are conceptually and computationally simple, while non-linear equalizers are complex and computationally intensive [4]. The cost of linear equalizers is less. On the other hand, non-linear equalizers are more complex, but they offer superior performance.

2. Types of Equalizer

Equalizer is used to reduce the intersymbol interference (ISI) at the receiver side. It can be classified as:

1) LMS Equalizer

Least mean squares (LMS) 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 (difference between the desired and the actual signal). The LMS Linear Equalizer block uses a linear equalizer and the LMS algorithm to equalize a linearly modulated baseband signal through a dispersive channel. During the simulation, the block uses the LMS algorithm to update the weights, once per symbol. When you set the Number of samples per symbol parameter to 1, then the block implements a symbol-spaced (i.e. T-spaced) equalizer. When you set the Number of samples per symbol parameter to a value greater than one, the block updates the weights once every N^{th} sample for a T/N-spaced equalizer [5].

2) RLS equalizer

The Recursive least squares (RLS) is an adaptive filter which recursively finds the coefficients that minimize a weighted linear least squares cost function relating to the input signals. This is in contrast to other algorithms such as the least mean squares (LMS) that aim to reduce the mean square error. In the RLS Linear Equalizer block uses a linear equalizer and the RLS algorithm to equalize a linearly modulated baseband signal through a dispersive channel. During the simulation, the block uses the RLS algorithm to update the weights, once per symbol. When you set the Number of samples per symbol parameter to 1, then the block implements a symbol-spaced (i.e. T-spaced) equalizer and updates the filter weights once for each symbol. When you set the Number of samples per symbol parameter to a value greater than 1, the block updates the weights once every N^{th} sample, for a fractionally spaced (i.e. T/N-spaced) equalizer.

3) CMA

CMA stands for constant modulus algorithm. The CMA Equalizer block uses a linear equalizer and the constant modulus algorithm (CMA) to equalize a linearly modulated baseband signal through a dispersive channel. During the simulation, the block uses the CMA to update the weights, once per symbol [10]. If the Number of samples per symbol parameter is 1, then the block implements a symbol-spaced equalizer; otherwise, the block implements a fractionally spaced equalizer [6].

3. Proposed Model

The model of OFDM using various equalizers is shown below in Figure 2.

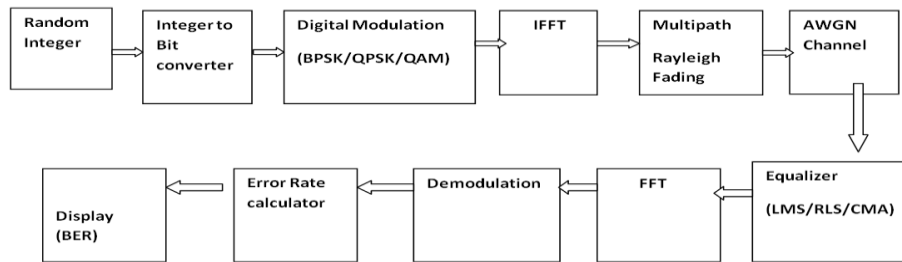


Figure 2. Proposed OFDM Model using Various Equalizer (LMS/RLS/CMA) for Different Digital Modulation

In this proposed work, the data is generated using Random integer and then integer to bit converter is used. After this the output of the converter is modulated by using digital modulation technique (BPSK, QPSK and QAM). Inverse fast Fourier transform is performed on the modulated signal and then the output of the IFFT is passed through multipath Rayleigh channel. The output of the channel is passed through various equalizer (LMS, RLS and CMA)[14]. Fast Fourier transform is performed on the equalized output and then it is demodulated. The demodulated output is passed through error rate calculator to determine the value of BER. The BER value is calculated for various equalization technique (LMS, RLS and CMA). A comparative analysis of BER is done for various equalization technique.

4. Simulink Results and Analysis

The proposed model of OFDM using LMS, RLS and CMA equalization techniques are simulated using Matlab Simulink. The simulation parameters are given below:

Modulation- BPSK, QPSK and QAM

Equalizer- LMS, RLS and CMA

Fading channel- Multipath Rayleigh, AWGN

The BER results using LMS, RLS and CMA equalizer for OFDM based BPSK system are shown in Figure 3-5.

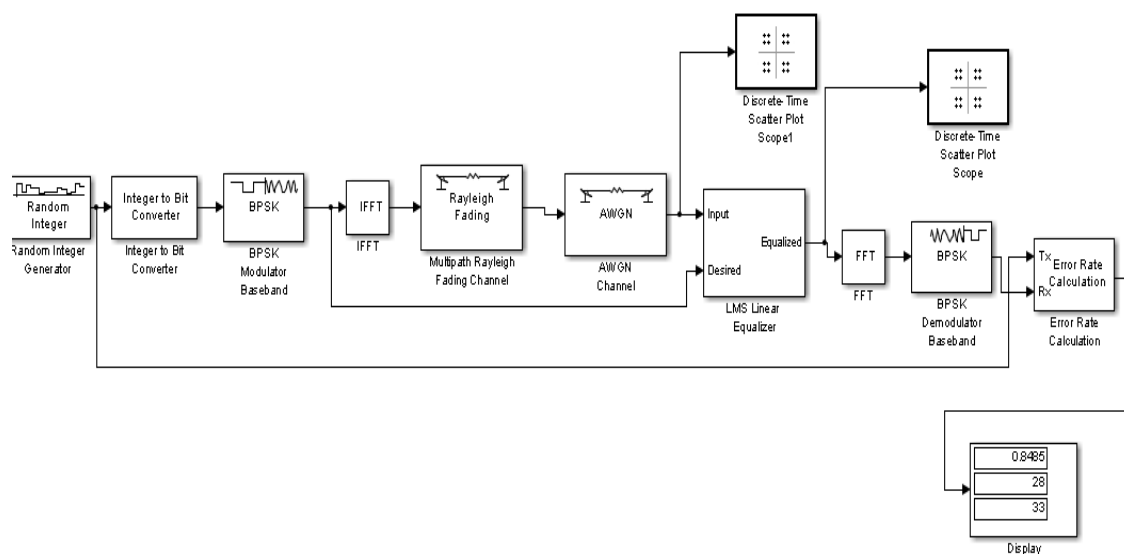


Figure 3. BER Analysis of LMS Equalizer for BPSK based OFDM System

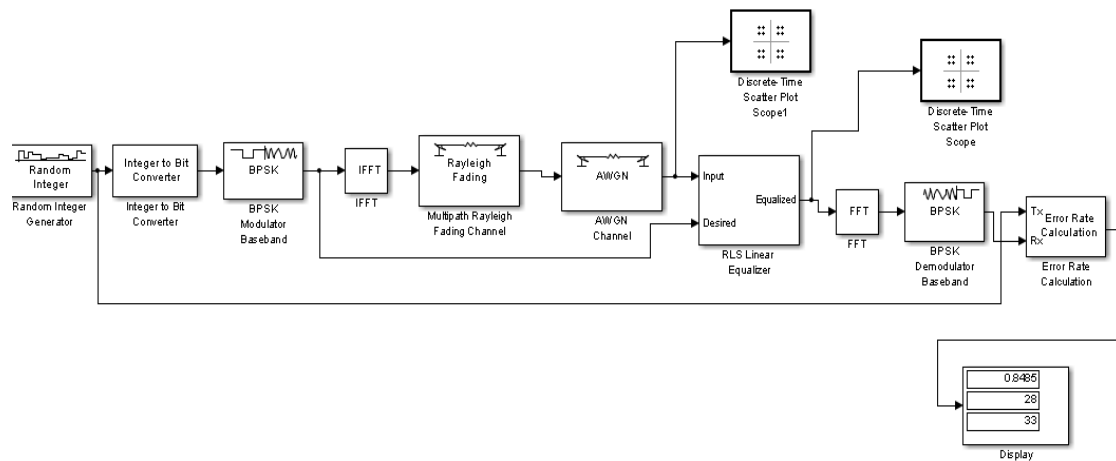


Figure 4. BER Analysis of RLS Equalizer for BPSK based OFDM System

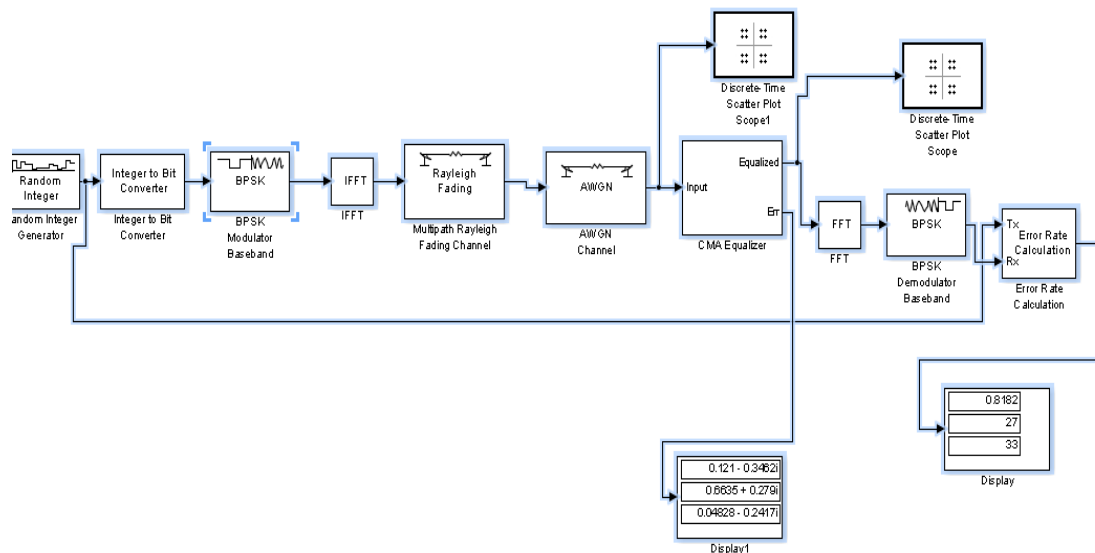


Figure 5. BER Analysis of CMA Equalizer for BPSK based OFDM System

The BER calculation for various equalization is shown in Table 1.

Table1 BER Results of LMS, RLS and CMA Equalizer for OFDM System

Equalization	OFDM based BPSK system	OFDM based QPSK system	OFDM based QAM system
LMS	0.845	0.909	0.878
RLS	0.848	0.878	0.934
CMA	0.818	0.939	0.878

From Table 1, the results shows that CMA equalizer has better BER results as compared to LMS and RLS equalizer and the bar char representation is represented in Fig. 6. The BER result of BPSK based OFDM system using CMA equalizer has least value as compared with QPSK and QAM based OFDM system. The BER calculation using LMS equalizer has better results as compared to RLS equalizer. So to model OFDM system using CMA equalizer is preferred over LMS and RLS equalizers.

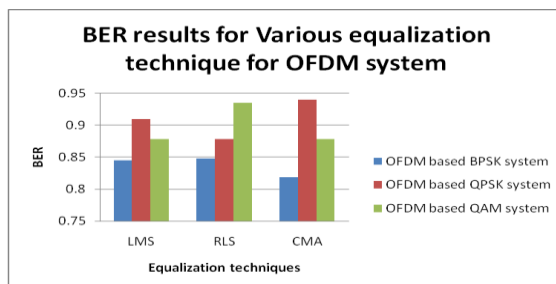


Figure 6. BER Analysis of Various Equalization Techniques for OFDM System

5. Conclusion

OFDM technique is widely used in wireless communication because of its very high data rate [11]. The performance of OFDM can be further enhanced by using various channel equalization methods such as LMS, RLS and CMA. The simulink results shows that the CMA equalizer in OFDM based BPSK system results in minimum value of BER as compared with LMS and RLS equalizer. The BER results are better in LMS than RLS .So CMA equalizer is used to enhance the performance of OFDM system.

References

- [1] Gurve AC, Wasnik SS, Yerlekar ABAS, Chide N. Study of OFDM Variants and Implementation of OFDM Using fft/ifft.
- [2] Luo BW, Zhang XY, Ren XK. On Applications of OFDM Technique. *Video Engineering*. 2006; 2: 005.
- [3] Colieri S, Ergen M, Puri A, Bahai A. *A study of channel estimation in OFDM systems*. In Vehicular Technology Conference Proceedings. VTC 2002-Fall. IEEE 56th, IEEE. 2002; 2: 894-898.
- [4] Rinne J, Renfors M November. *Equalization of orthogonal frequency division multiplexing signals*. In Global Telecommunications Conference. GLOBECOM'94, Communications: The Global Bridge. IEEE. 1994: 415-419.
- [5] Kao YA, Lee SK, Hsiao CL, Chio PL. *One-Tap Frequency Domain LMS Equalizer for OFDM Systems*. ISCOM. Taiwan. 2003.
- [6] Elangovan K. *Comparative study on the channel estimation for OFDM system using LMS, NLMS and RLS algorithms*. In Pattern Recognition, Informatics and Medical Engineering (PRIME). International Conference on IEEE. 2012: 359-363.
- [7] Glisic SG. *Advanced wireless communications*. Wiley-InterScience. 2005.
- [8] Ahmed MT, Khalid J, Noori K, Haider SA. *Bit Error Rate Comparison of OFDM and MC-CDMA Systems*. In Computer Science and Information Technology, ICCSIT'08. International Conference on IEEE. 2008: 665-668.
- [9] Marchetti N, Rahman MI, Kumar S, Prasad R. *OFDM: Principles and challenges*. In New directions in wireless communications research. Springer, US. 2009: 29-62.
- [10] Asharif F, Tamaki S, Alsharif MR, Ryu HG. Performance Improvement of Constant Modulus Algorithm Blind Equalizer for 16 QAM Modulation. *International Journal on Innovative Computing, Information and Control*. 2013; 7(4): 1377-1384.
- [11] Reddy B, Lakshmi B. Channel estimation and equalization in OFDM receiver for WiMAX with Rayleigh distribution. In Advanced Electronic Systems (ICAES), International Conference on IEEE. 2013: 337-339.
- [12] Idris A, Ya'acob N, Sulong SM, Sarnin SS. *Reduction of ISI using different equalization of adaptive algorithm for mobile WiMAX communication system*. In Wireless Technology and Applications (ISWTA), IEEE Symposium on. 2014: 75-80.
- [13] Denno S, Saito Y. Fast channel impulse response estimation scheme for adaptive maximum likelihood sequence estimation equalizer-proposal of variable-gain least mean square algorithm. *Electronics and Communications in Japan (Part I: Communications)*. 1996; 79(7): 104-115.
- [14] Muhmmad Anjum, Mussa A Dida, MA Shaheen. Peak Power Reduction Using Improved Selective Mapping Technique for OFDM. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2014; 12: 6291-6296.
- [15] Manhas P, Soni MK. OFDM PAPR Reduction Using Recurring SLM with Cyclic and Linear Block Codes Schemes. *Indonesian Journal of Electrical Engineering and Computer Science*. 2015; 16(1): 1-6.