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Common Phase Error Correction and Equalization of a Signal with Tilted Phase

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Abstract: ***Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation technique. In this scheme, there are subcarriers that are orthogonal to each other and closely spaced. These subcarriers will be converted to parallel streams. There are channel impairments like Clock Frequency Offset (CFO), Chromatic Dispersion (CD), and polarization Mode Dispersion (PMD) that affect the performance of the OFDM system. This can cause tilting of OFDM signal i.e, Common Phase Error (CPE) on the OFDM symbol. This CPE is compared with the skewed image in image processing domain and algorithm like Minimum Bounding Box (MBB) and Best fit Bounding Box (BBB) can be used for its correction. Traditional methods for CPE correction is also simulated and algorithms implemented are Least Mean Square (LMS) and Constant Modulus Algorithm (CMA).Traditional methods for channel equalization like Least Mean Square (LMS) and Constant Modulus Algorithm (CMA) are simulated in this work. LMS is a pilot aided method and CMA is a blind equalization method. The convergence rate of LMS is greater than CMA but the spectral efficiency is reduced due to the requirement of training sequence. CPE can be compared with the skewed image in image processing and algorithms like Minimum Bounding Box (MBB) and Best-Fit Bounding Box can be used for its correction. MBB and BBB algorithms are implemented and its performances are compared. The performance comparison is based on Bit Error Rate and BBB is found to have lower BER than MBB. BBB algorithm has less computational complexity and better spectral efficiency than MBB.***

Keywords: Skewed image, CPE**,** Image processing, MBB, LMS,CMA

1. Introduction

In modern communication, data rate is one of the most important factor that's being considered by service providers inorder to meet the requirements of their customers. Its essential for the service providers to incorporate large number of users in a limited bandwidth. OFDM is a multicarrier modulation technique that has the potential to accommodate many number of users. Fiber OFDM systems can be categorized into Direct Detection Optical (DDO) and Coherent Detection Optical (CO) systems. A single photodiode is only required in DDO systems whereas coherent detection systems optical mixing is used. CO-OFDM has greater tolerance to dispersion and OSNR requirements makes it preferable for long distance communication.

OFDM is a reliable and efficient scheme that can be utilized to transmit data even in multipath environments. Orthogonality helps us to reduce interference and hence it allows multipath data to be sent across in a common channel. Guard period can also be used to reduce the effect of Inter Symbol Interference(ISI) on an OFDM signal. Guard period or Cyclic Prefix(CP) is prefixing of a symbol with a repetition of the end. CP as two important functions eliminates ISI and allows frequency domain processing such as channel estimation and equalization. The major drawback of OFDM systems is that it is greatly prone to phase noise which is created by oscillators.

CPE and Inter Carrier Interference(ICI) that arise due to phase noise. CPE is common rotation of all constellation points in a complex plane and ICI is more like Gaussian noise. OFDM receivers are very sensitive to phase noise. Traditional methods are Pilot Aided(PA) and blind channel estimation methods. In PA method, channel estimation is done by using pilot sequence and symbol which are inserted into some fixed positions of signals sent by transmitter. Hence it lowers the spectral efficiency and power utilization. Blind channel estimation is focused at the finding the similarity between the data sent and received without any knowledge about transmitted data. Incontrast to the PA scheme, it gives higher spectral efficiency and power utilization but it needs more data for analysis. In this paper, MBB and BBB used to compensate CPE using image processing technique for OFDM system is implemented and simulated using MATLAB R2015b software. MBB and BBB algorithms are used for skewness correction in image processing. Considering an OFDM symbol with CPE, it has lot of similarity to a skewed image. LMS algorithm and CMA algorithms used for channel estimation and equalization are also implemented in the same

In section 2, system overview is discussed. The OFDM system is explained in section 3. In section 4 and 5, MBB, BBB, LMS and CMA algorithms are briefed. Simulation results are explained in section 6. Finally, the work is concluded and future scope is discussed in section 7.

2. System Overview

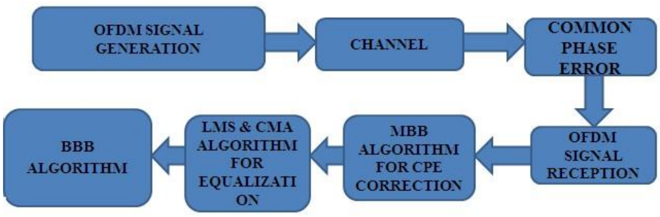

Figure 1: System Overview

The channel state information is used to obtain the channel properties which can be achieved using blind channel estimation and pilot based channel estimation. This information describes how a signal gets propagated from transmitter to receiver and represents the combined effect of power decay, fading, scattering, etc with distance[9].

The system overview is shown in figure 1. First of all an OFDM signal is generated. Its transmitted through a channel which is Additive White Gaussian in nature and in this channel the CPE is induced. At the receiver, an OFDM signal is received with CPE is obtained. Then MBB and BBB algorithms are implemented to correct the CPE. Then LMS and CMA algorithm is also implemented for channel equalization.

3. OFDM Signal Generation and Reception

OFDM signal is generated by modulating the input data using Quadrature Amplitude Modulation (QAM). QAM has efficient conservation of data rate. Then the serial data is converted to parallel data streams and each of them are modulated by orthogonal subcarriers using Inverse Fast Fourier Transform(IFFT). Pilot symbols and CP are added. The data is again converted back to serial format and is transmitted. Its transmitted through an AWGN channel. The channel impairments causes phase shift on individual subcarriers, i.e, CPE is induced.

At the receiver, data is converted to parallel bit streams and then CP and pilot symbols are removed. After FFT operation, Demodulation and demapping is done and data is converted back to serial data and is received as explained in the below figure.

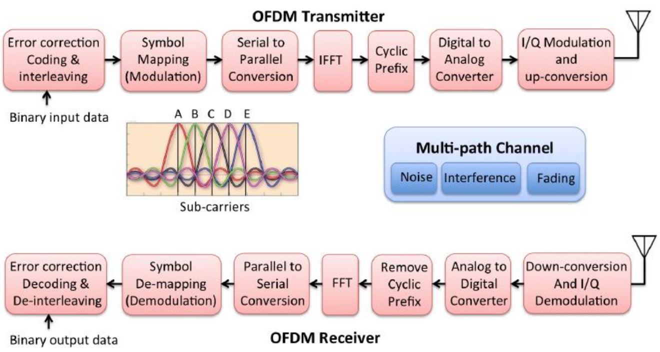

Figure 2: OFDM transmitter and receiver

4. Minimum Bounding Box(MBB)

The phase noise induces common rotation to all subcarriers in one OFDM symbol even after coherent detection and traditional demodulation procedures. The following figure shows a skewed image and it can be compared with the constellation diagram of a 16-QAM mapping. This can be considered as a square with skewness of angle θ. The bounding box is the minimum out rectangle in horizontal direction that can cover all the constellation points [1]. The area of the bounding box is a function of the tilt angle and reaches minimum when the constellation is squared [1].

Figure 3: Skewed image

The above show is an example of skewed image. Considering the constellation diagram of CPE affected signal as shown below.

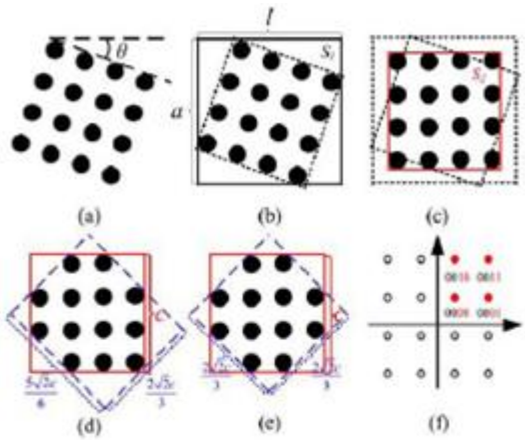

Figure 4: Principle of MBB

The reduction in area of the bounding box makes the recovery of the phase shift possible. The area can be measured using the following equation:

$$A(\psi_k) = l.a \quad (1)$$

Where l and a are the lengths of 2 sides of the bounding box. The suitable estimated phase can be determined at the test phase that minimizes the area A

$$\theta' = \arg\min(A(\psi)) \quad (2)$$

The major computation needed is the measurement of the area A and hence the computational load is minimized. The ambiquity can be discarded by using one TS and the rest can be used for transfer of data. This technique can be applied to 32-QAM and 128-QAM as well with different constellations. The bounding box is determined using the outer part of the constellation and thus the inner part can be discarded. The phase shift can be recovered even if some of the outer points are not present.

5. LMS and CMA

Adaptive equalization is technique that automatically adapts to time varying properties of the communication channel [7]. Conventional methods for channel equalization in an OFDM system are pilot aided and non pilot aided or blind equalization method. There are different techniques in pilot aided method such as LMS, LMSE, MMSE, etc. Phase shift compensation using LMS equalizer is obtained.It is one of the popular method used for adaptive channel equalization. The criterion used in this is to minimize the Mean Square

Error (MSE) between the desired equalizer output and actual equalizer output [7].

$$Error = desiredoutput - actualoutput \qquad (3)$$

The basic relation used in LMS algorithm is

$$w(n+1) = w(n) - \alpha e^{*}(n)u(n) \qquad (4)$$

From equation (4), $u(n)$ is the input signal, $w(n)$ is the equalizer filter taps and α denotes the step size and it controls the rate of convergence [7].

CMA equalizer that belongs to blind equalization method can also be used for phase shift compensation. It correlates the data sent and received and estimates the signal received. It needs more data for analysis but no pilot or training symbols are required. Let $s(n)$ be the input to the channel and $x(n)$ be its output, which is the noisy and distorted version of $s(n)$. Let an equalizer be used to remove the channel distortion from the received signal. If f is the tap-weight vector of the equalizer of length L, the output of the equalizer $y(n)$ and $x(n)$ be the input vector can be represented [8] by:

$$Y(n) = f^{H} X(n) \qquad (5)$$

6. Simulation Results

The implementation tool used isMATLAB R2015b. The OFDM signal is given as the input. MBB, LMS and CMA algorithms are implemented at the receiver section.MBB algorithm is based on the area calculation of the bounding box and estimating the phase shift. LMS algorithm needs training symbols to obtain an estimate of the channel and its an iterative method that requires the equalizer weights to be adjusted. For CMA, no training symbols are required. The transmitted signals statistics and properties is only needed to equalize the phase shift.

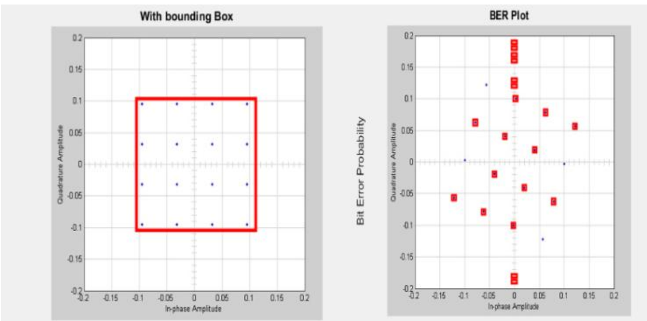

Figure 5: Signal constellation with bounding box

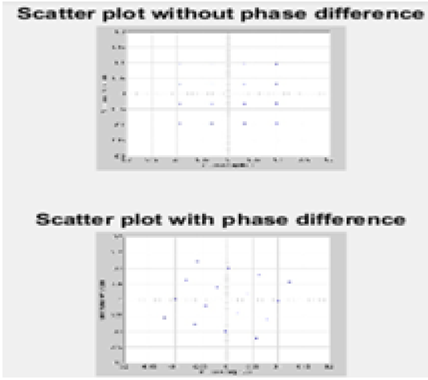

Figure 6: Scatter plot with and without phase difference

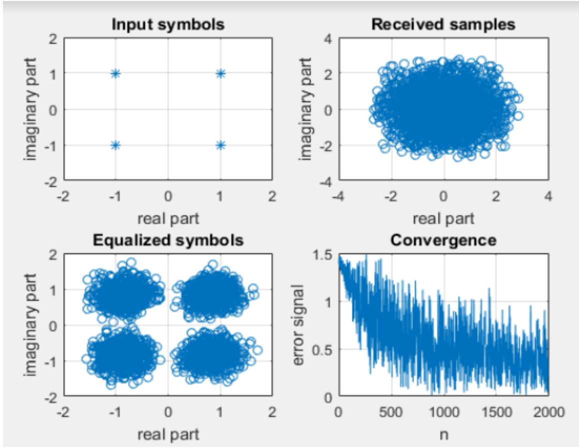

Figure 7: Equalization using LMS algorithm

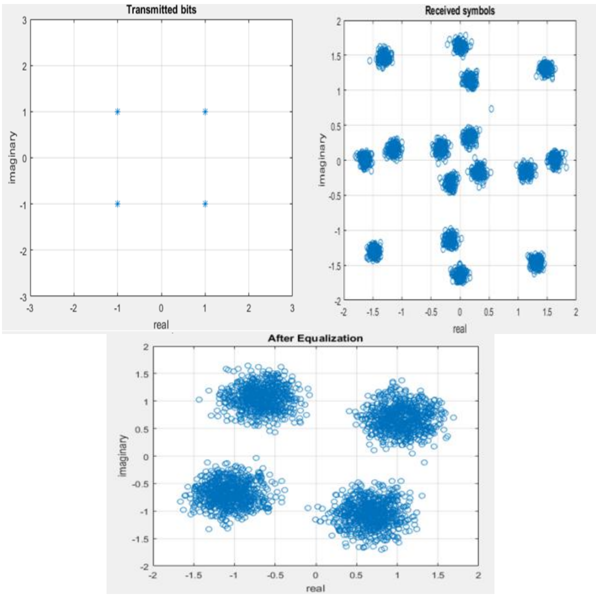

Figure 8: Equalization using CMA algorithm

7. Conclusion

A CPE estimation method based on MBB, which is a common image processing technique is implemented. LMS and CMA algorithms are used for channel equalization are the conventional techniques. CMA is simpler, good performance and robustness. The LMS algorithm has fast convergence than CMA but needs extra computations. But MBB algorithm has less computational complexity than the traditional techniques like LMS and CMA. MBB algorithm is less complexity and hardware requirements are fewer as well.

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References

[1] Tianwai Bo, Lingchen Huang, and Chun-Kit Chan,"Channel estimation on individual subcarrier using image processing in optical OFDM system," IEEE Photon. Technol. Lett., vol. 27, no. 15, pp. 1597 1600, Aug. 1, 2015.
[2] Zhenming Yu, Yiming Lou, Minghua Chen, Hongwei Chen, Sigang Yang, and Shizhong Xie, "Phase estimation methods using Pilot and non-pilot aided approaches," IEEE Photon. Technol. Lett., vol. 28, no. 15, pp. Aug.1, 2016.
[3] T. Bo, L. Huang, and C.-K. Chan, "Blind Channel Estimation for MIMO-OFDM Systems," IEEE Transactions On Vehicular technology,vol. 56,no.. 2, March 2007.
[4] M. Sarfraz and Z. Rasheed, "Skew estimation and correction of text using bounding box," in Proc. 5th Int. Conf. Comput. Graph., Imag., Vis., Penang, Malaysia, Aug. 2008, pp. 259–264.
[5] X. Yi, W. Shieh, and Y. Tang, "Phase estimation for coherent optical OFDM," IEEE Photon. Technol. Lett., vol. 19, no. 12, pp. 919–921,Jun. 15, 2007.
[6] T. Bo, L. Huang, and C. K. Chan, "Common phase estimation in coherent OFDM system using image processing technique," IEEE Photon. Technol. Lett., vol. 27, no. 15, pp. 1597–1600, Aug. 1, 2015.
[7] Sanjana T and Suma M N, "Comparison of channel estimation and equalization techniques for OFDM systems," Circuits and Systems: An international journal (CSIJ), Vol. 1,No. 1, January 2014.
[8] Joshua Madhukar Sing1, Alisha Khan, Akansha Gupta, Vipul Pathak and Rohit Sindhvani, "Performance Evaluation of CMA Blind ChannelEqualization for 4-QAM Modulation," International Journal of Emerging Trends & Technology in Computer Science (IJETTCS)Volume 3, Issue 2, March – April 2014.
[9] Vineetha Mathai, K. Martin Sagayam, " Comparison and analysis of channel estimation algorithms in OFDM systems," International Journal of Scientific and Technology Research Volume 2, Issue 3, March 2013.

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