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HYBRID DOMAIN EQUALIZATION IN OFDM FOR THE REDUCTION OF OPTICAL LED NONLINEARITY

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Abstract - Nonlinear distortions in Light Emitting Diodes (LEDs) present difficulties for optical wireless communication systems, notably those using Orthogonal Frequency Division Multiplexing (OFDM). In order to lessen the effects of optical LED nonlinearities in OFDM systems, a unique strategy called hybrid domain equalization is proposed in this study as a solution to the problem. The method efficiently suppresses nonlinear distortions by combining the strengths of frequency domain equalization and time domain equalization. The research illustrates the efficiency of the suggested approach in lowering optical LED nonlinearities, improving system performance, and enabling dependable high-speed data transfer in optical wireless communication systems through simulations and performance tests. The results highlight the potential of hybrid domain equalization as a promising answer to the nonlinear distortion problem in the context of OFDM-based optical wireless communication systems.

Key Words: Orthogonal Frequency Division Multiplexing (OFDM), Light Emitting Diodes (LEDs)

I.Introduction

For high-speed data transmission in a variety of communication systems, including optical wireless communication, orthogonal frequency division multiplexing (OFDM) has become a well-known modulation technology. However, nonlinear distortions can considerably impair system performance in optical wireless communication systems using Light Emitting Diodes (LEDs) as transmitters. The possible data rates are constrained by these nonlinearities, which are brought on by the inherent features of LEDs and induce inter-symbol interference.

This work offers a novel strategy termed "Hybrid Domain Equalization" to deal with the issue of optical LED nonlinearities in OFDM systems. By combining frequency domain equalization and time domain equalization, the suggested method seeks to reduce the effects of nonlinear distortions. The method aims to efficiently reduce nonlinear distortions and improve the overall performance of OFDM-based optical wireless communication systems by integrating these two equalization domains.

Hybrid domain equalization's justification comes in its capacity to capitalise on the advantages of both frequency and temporal domain equalization methods. Time domain equalization is effective at reducing intersymbol interference brought on by nonlinearities, whereas frequency domain equalization excels at handling frequency-selective channels. The technique seeks to provide a comprehensive solution that successfully addresses the problems caused by optical LED nonlinearities by merging these areas.

The theoretical foundations of the hybrid domain equalization technique will be covered in detail in this paper, along with how the use of both frequency and time domain equalization helps reduce nonlinear distortions. The study will also show simulation findings and performance assessments to show how the suggested approach effectively reduces optical LED nonlinearities and boosts system performance.

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Hybrid domain equalization has effects that go beyond just reducing distortion. The method has the potential for allowing larger data rates, longer transmission distances, and improved reliability by successfully addressing the nonlinearities in OFDM-based optical wireless communication systems. These benefits are essential for utilising optical wireless communication systems to their full potential in a variety of application scenarios, including indoor communication settings where LEDs are frequently utilised.

As a strategic answer to the issue of optical LED nonlinearities in OFDM-based optical wireless communication systems, this work offers the idea of hybrid domain equalization. The approach's technological specifics, advantages, and prospective effects on the field of optical wireless communication will all be covered in more detail in the parts that follow.

II. Setup for System

1Setup for System Model and Simulation:

Create a system model that appropriately depicts the LED transmitter-based OFDM optical wireless communication system.Give details about the channel model and the optical LED nonlinearities.

2.Algorithm for Hybrid Domain Equalization

Create the Hybrid Domain Equalization algorithm, which combines time domain and frequency domain equalization. Create an algorithm that takes into account the nonlinear distortions caused by optical LED nonlinearities.

3. Data Transmission and Generation:

Create symbols for OFDM that represent data streams for transmission.Pre-process the data symbols using the Hybrid Domain Equalization technique before transmitting them.

4. Injection of Nonlinearity:

Models that mimic the effects of LED nonlinearity are used to introduce nonlinear distortions into the transmitted data.To evaluate the effectiveness of the Hybrid Domain Equalization technique under various circumstances, include changing levels of nonlinearity.

5. Demodulation and Equalization

Use the distorted data that was received to apply the Hybrid Domain Equalization method.To reduce nonlinear effects and intersymbol interference, do frequency domain equalization and time domain equalization in that order.

6.Performance Measurements:

To measure the performance of the system, define performance metrics like Bit Error Rate (BER) and Signal-to-Noise Ratio (SNR).Calculate these measures for different signal-to-noise ratios and nonlinear distortion levels.

7. Simulation Architecture:

Use MATLAB or comparable tools to implement the system model and Hybrid Domain Equalization technique in a simulated environment.Multiple iterations of the transmission, reception, and equalization processes should be simulated.

8.Compare and contrast:

Compare the effectiveness of the proposed hybrid domain equalization technique to more established time and frequency domain equalization techniques.BER and SNR gains made possible by hybrid domain equalization should be evaluated in light of various nonlinear distortion scenarios.

9. Analysis of Sensitivity

Analyse how responsive the Hybrid Domain Equalization method is to different levels of LED nonlinearity, channel characteristics, and equalization parameters.

10. Considerations for Real-World Implementation:

Examine whether employing the Hybrid Domain Equalization technique in actual optical wireless communication systems is practically feasible.Address potential difficulties with synchronisation, processing demands, and device complexity.

III. LED NONLINEARITY AND THE MODULATION

Linear distortions and nonlinear distortions are the two main categories of distortions in a nonlinear OFDM system. In the frequency domain, linear distortions brought on by channel fading are easily equalised. However, it is particularly challenging to adjust for nonlinear distortions that lead to interferences between subcarriers in the frequency domain.

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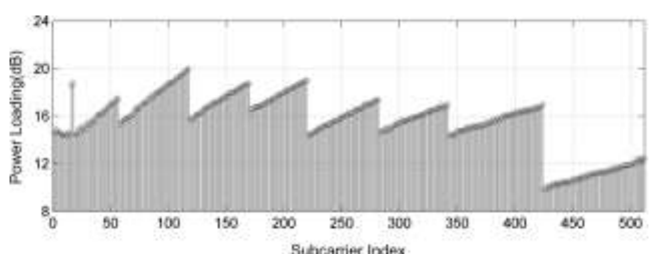
The approach we suggested uses frequency domain equalization (FDE) to correct linear distortion and nonlinear distortion equalization (N-TDE) to correct nonlinear distortion. For maximising the possibilities of VLC systems, two OFDM schemes—fixed-rate and bit-power loading—have been used [8]. In our trials, the N-TDE is used to test both strategies. Fig. 1 displays the block diagram of the N-TDE-based, OFDM-based VLC system. Pre-frequency domain equalization (pre-FDE) or adaptive power loading are used after the operation of quadrature amplitude modulation (QAM). In order to provide an output signal with a real-time domain, Hermitian symmetry of complex signals is then applied before the inverse fast Fourier transform (IFFT). To reduce inter-symbol interference, the cyclic prefix (CP) is added. After synchronisation, three equalization methods are tested at the receiver.The nonlinearity in VLC systems primarily results from LEDs. The main cause of LED nonlinearity is related to thermal properties of LEDs, which cause a decrease in electrical-to-optical (E/O) conversion efficiency (light output of the LED declines and gradually approaches a steady-state value; LED self heating characteristic) [14].



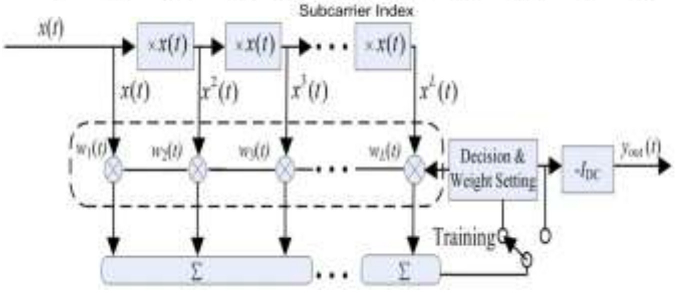


Fig. 1.Structure of Time Division Equalizer

A commercially available white-LED (Cree PLCC4)'s E/O characteristic is measured in Fig. 2(a) using various biassing currents, and the high nonlinearity is evident. As shown in Fig. 2, the positive and unipolar signal must be modulated onto the LED's luminous intensity in VLC systems. For the bipolar signal, negative values are always shifted to positive values using the direct-current-bias (DC-bias). Therefore, Psignal (signal peak to peak) and DC-bias are the two elements that most strongly influence nonlinear distortion. The modulation index (MI) and DC-bias index (DI), which are measured using an avalanche photo diode (APD) in our studies, are defined in Fig. 2(b) to help deepen our understanding of the nonlinear phenomenon.

III. BER Performance

The bit-power loading scheme's effect on BER performance in relation to MI is shown in Figure 10. It can be seen that experimental outcomes for bit-power loading and fixed-rate are comparable. The L-TDE performs similarly to without TDE, suggesting that nonlinear noise predominates in system performance. The nonlinear noise will gradually increase as the MI increases. The amplitudes of the OFDM symbols exceed the maximum linear interval as the MI rises and operate in a nonlinear range. The BER performance, however, can be greatly improved and the constellations can be distinguished clearly when the nonlinear compensation is in use. There are five OFDM symbols in the N-TDE training sequence.

Fig 2. Optimal Power Distribution

IV.Modulation Index

n terms of the mean squared error (MSE) between the perfect and received symbol the convergence of N-TDE is then provided. A series of 5 OFDM symbols is used to train the N- TDE. The N-TDE of second order and third order's convergence speed and steady state error performance are displayed in Figures 13(a) and 13(b). The MSE can be decreased by the N-TDE of third order,

However more convergence iterations are needed than with the N-TDE of second order. One intriguing finding for practical applications is that the steady state error can be attained with just one OFDM symbol.

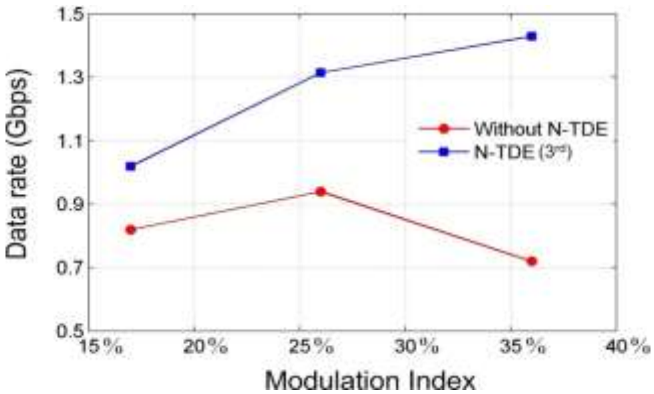


Fig 3.Modulation Index

VI.Conclusion

This work presents an effective nonlinear compensation strategy for VLC systems based on OFDM. The hybrid nonlinear equalization we proposed is tested with two different methods (adaptive bit-power loading). The results of the studies demonstrate how the N-TDE is a powerful, low-complexity, and adaptable equaliser for reducing LED nonlinearity. The quadratic distortion can be greatly decreased with just a few simple adjustments. It is shown that the N-TDE can significantly improve the BER performance and the ideal LED MI. Nonlinear compensation allows for the elimination of both in-band and out-of-band noise. It is important to note that the other optically OFDM systems can use the proposed negative compensation mechanism.

VII.Reference

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