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Improvement of Multipath Channel Performance for Optical MIMO-OFDM in LED Modulation with Fully Generalized Spatial-Frequency

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Abstract. This paper suggests a scheme to generalize the idea of LED index modulation concept by using the spatial multiplexing principle to relay complex OFDM signals through various channels such as AWGN, Rayleigh and Rician by splitting these signals into their real-imaginary and positive-negative components. In order to combat ISI as well as to increase the channel capacity. The MIMO-OFDM efficiency analysis, taking into account the constraint of the forward current of the LED is extracted. The accuracy of the theoretical results is verified by comparing the Bit Error Ratio (BER) reduction and improvement to the (SNR) results under varying condition of the channel. Using MIMO-OFDM as next-generation techniques, along with QAM aims to provide development of new concepts that will lead to the growth of future optical communication. Simulation results validate data rates gained over optical communication using LED modulation scheme and the pure transmission diversity method.

Keywords. OWC, VLC, LED modulation, MIMO-OFDM, FGIS.

1. Introduction

The LED Visible Light Communication (VLC) has recently been a big contender for future wireless communication. As a convincing wireless networking technology proposed to address the deficiencies of RF multimedia applications successfully, outside conventional radio frequency (RF) networking, VLC provides many benefits, such as high quality, no requirement for a licence, sensitivity to electromagnetic interference, basic device efficiency and high safety. Due to a mixture of lighting and networking, a substantial number of empirical studies have concentrated on high-speed indoor transmitting in VLC technologies. Similarly, the restricted transmitting throughput of commercial LEDs restricts the transmitted data rate, where signals modulated at different speeds are severely attenuated due to the spatial properties of LEDs.

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2. Related Works

The OFDM definition provides the best data rate coverage where the pace is found to be drop [1]. The MIMO idea has increased frequency, but the data coverage has been found to be low [2]. The MIMO-OFDM concept helps to improve both achievable rate and BER upto 6.25 by saving GLIM[4]. LCF and LFF systems have greater sum-throughput while transmitting less feedback compared to the realistic one-bit feedback process[5]. MIMO in VLC, MIMO-SSD which has a normal frequency of 5 MHz and a standard data rate of 100Mbps except 300Mbps in the OFDM[6]. LiFi, F-GSM, F-QSM concepts have 5MHz with low data rate below 100[7]. LED selection are applicable to decorrelate channels for performance enhancement. The collection of MAP and LEDs leads to major efficiency gains and has been shown to achieve a high data rate with reduced speed [8]. It is then concluded that the idea of the MIMO-OFDM is the optimal concept[3]. FGIS system is the resonant frequency used when the data rate is considered to be unstable at enhanced speed[9].This was discovered to be the most powerful network, with an uniform intensity, power output, and strength [10].

3. Proposed System

The proposed scheme generalises the (OFDM) and (MIMO) approaches which have been found especially Enticing in reaching a high throughput, these can even be blended together in the optical transmission system. By OFDM modulation, the signal is analyzed in different frequency-flat channels and (ISI) can be omitted, whereas the MIMO scheme increases spectral efficiency and enhances stability based on the basic concept of communicating streaming data concurrently to several LEDs.Even then, the similarity of the different MIMO channels is a major limitation of MIMO efficiency. The conventional MIMO Rayleigh fading channel system, which connects specific data streams concurrently to multiple LEDs, has been shown to be only useful with a limited channel correlation.In this way, we will take control of all MIMO schemes. In Figure 1 the switching MIMO method is developed for the specified MIMO OFDM system, where modulation instructions are stable for all OFDM sub-channels. The transmission diversity method must use a greater signal constellation size to accommodate a large bandwidth, resulting in a weaker bit error rate (BER) output.

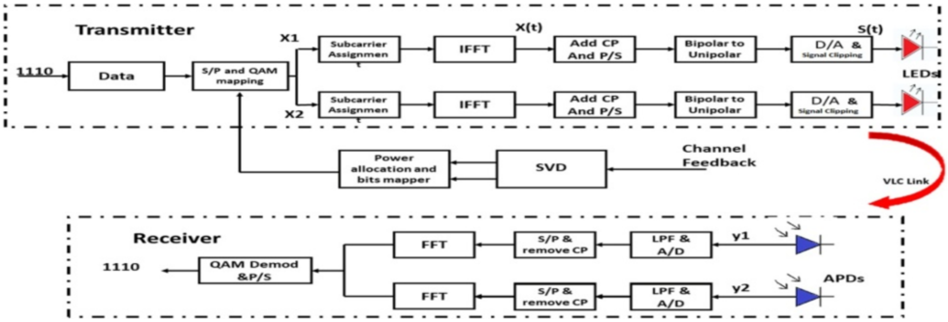


Figure 1. Block Diagram of Proposed System

3.1. LMMSE Algorithm

In Optical Wireless Systems using Spatial OFDM, The pilot will then be given to all sub-carriers with only a fixed amount of time. Because the channel is stable throughout the block, the channel is indifferent to bandwidth sensitivity. Because pilots have been sent to both airlines, there is no quantization mistake. The approximation could be made by using LMMSE.

$$h_{LMMSE} = X^{-1}y$$
$$where \quad X = diag\ \{x_0, x_1, \cdots x_{N-1}\}$$
$$y = \begin{bmatrix} y_0 \\ \vdots \\ y_{N-1} \end{bmatrix} \longrightarrow (1)$$

Here xi seems to be the pilot value transmitted by the ith subcarrier and yi is the value obtained by the ith subcarrier. When the time domain channel vector g is Gaussian and not associated with the noise power, the spatial frequency LMMSE approximation of g is given.

$$h\,LMMSE = FR_{gy}R_{yy}^{-1}y \quad where$$
$$F = \begin{bmatrix} W_N^{00} & \cdots & W_N^{0(N-1)} \\ \vdots & \ddots & \vdots \\ W_N^{(N-1)0} & \cdots & W_N^{(N-1)(N-1)} \end{bmatrix} and$$
$$W_N^{nk} = \frac{1}{N}e^{-j2\pi\frac{n}{N}k} \longrightarrow (2)$$

From which the Rgy is cross-covariance matrix between g and y and Ryy is the auto-covariance matrix of y. If the channel fades slowly, the channel prediction inside the block can be modified by using decision-return equaliser at each subcarrier. The decision feedback equaliser for the kth subcarrier can be defined as follows: The signal reaction of the kth subcarrier calculated either from formulated {He(k)} is being used to locate the approximate transmit signal {Xe(k)}.

$$X_e(k) = \frac{Y(k)}{H_e(k)} \quad k = 0,1,\cdots N-1 \longrightarrow (3)$$

Xe(k)}is encoded to binary data by "signal demapper" and then recovered by "signal mapper" as Xpure(k)}. The approximate channel {He(k)} is modified as follows:

$$H_e(k) = \frac{Y(k)}{X_{pure}(k)} \quad k = 0,\cdots N-1 \; (4) \longrightarrow$$

Figure 2 represents the working diagram of the LMMSE algorithm While channel fading is quicker, there is a balance between the error of calculation due to thresholding and the error due to the lack of channel monitoring. OWC has many attractive features, including reduced cost, poor throughput, non - licensed power consumption and versatility.

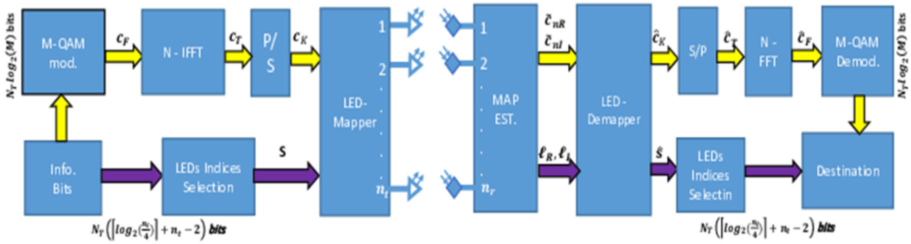
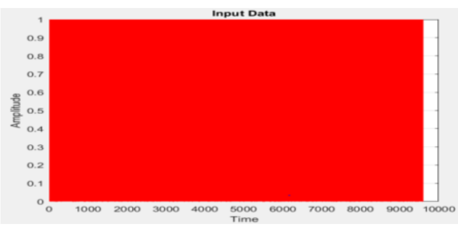


Figure 2. Working model of LMMSE Algorithm

OWC has many useful applications, such as high efficiency, highly secure, non - licensed capacity and usability. The sequences in LMMSE Algorithm are Input data, Convolutional encoding process, QAM Modulation, IFFT data subcarrier signal generation, Cyclic extended data, OFDM signal through channel, BER for LED Modulation.

4. Result and Discussion



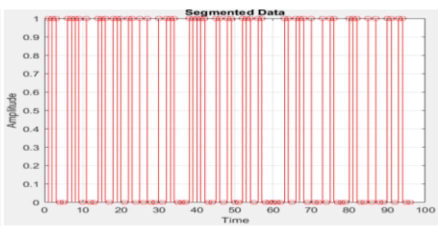
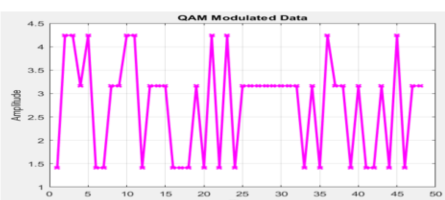


Figure 3. Input Data **Figure 4.** Segmented Data

In figure 3, the input data with baudrate 9600 bits which is also expressed as 9.6Khz for serial communication and the information bits are shown as amplitude with respect to time. Figure 4 represents the generated data converted into symbols by allotting 96 bits for each symbols. Therefore 9600bits are converted into 100 symbols thus segmenting the data.



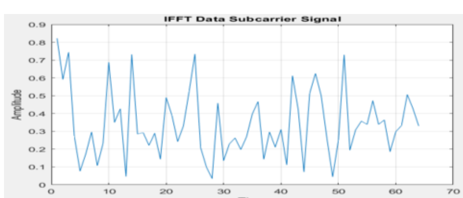


Figure 5. QAM modulated data **Figure 6.** IFFT Data subcarrier signal

The binary data is encoded using convolutional encoder and is shown in Figure 5.The 96bits representing each symbol is converted to 192 bits and then sent to matrix interleaver as the QAM modulator will accepts only the matrix data and not the sequence data. Figure 6 represents the pilots data is placed at the beginning and also inserted after every 13 bits.

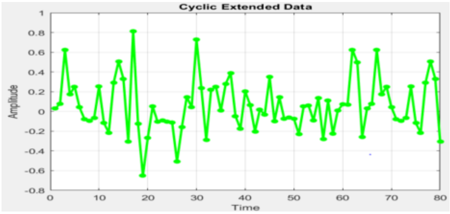


Figure 7. Cyclic Extended Data

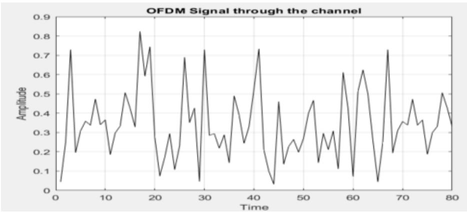


Figure 8. OFDM signal through the channel

The cyclic extension is performed by applying cyclic prefix and it is obtained as shown in Figure 7. Here the last 16bits are taken and placed in the first 16bits location and from the 17th bit onwards the IFFT data. To transmit the data after cyclic extension in OFDM scheme, channelization is performed where AWGN is introduced into the data at the channel. The OFDM segmented data through the channel is shown in Figure 8.

5. Conclusion

This work involves multipath channel performance improvement of optical MIMO-OFDM with fully generalized spatial-frequency LED modulation. This is performed to study the spectral efficiency of OFDM transmit in 3 different channels by changing and improving parameter. The LMMSE equalization and synchronization in VLC network helps to increase handover efficiency, throughput, and channel gain. The characteristics of optical wireless communication at different band width can be measured and the advantage of incredibly wide band width are explored which can be used to increase throughput and channel gain in other multipath scheduling algorithm as future scope.

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