AN IMPLEMENTATION OF MIMO AND OFDM BASED VISIBLE LIGHT COMMUNICATION SYSTEM

Prasanjeet Charpe[1]
M. Tech Scholar
Kalinga university, Kotni, Naya
Raipur, Chhattisgarh, India

Dr. Sunil Kumar[2]
Head of the Deaprtment (ECE)
Kalinga university, Kotni, Naya
Raipur, Chhattisgarh, India

Sailesh Deshmukh[3]
Assistant Professor (EE)
Kalinga university, Kotni, Naya
Raipur, Chhattisgarh, India

Abstract*—.Visible light communication with Visible light positioning (VLP) has been independently researched broadly because of the wide application and excellent performance of light-emitting diode (LED). In this paper, we describe a new innovative vlc system that has a better performance and efficiency to another previous system. We used the multiple-input multiple-output (MIMO) with the orthogonal frequency division multiplexing (OFDM) technique, which is to enhance the data rate of wireless data transmission. Since we know the multiple transmitter and receiver having different links distances, having various temporal delays, complex channel gain and phase differences are resulting when frequency domain have transformed. In OFDM, each subcarrier, the calculation of the corresponding precoding matrix in the frequency domain for the elimination of multiple interferences. We first considered phase information in the frequency domain, where precoding is uses of intricate patterns, real, channel matrices. Which is used to reduces the channel correlation to achieve better performance? This paper describes a detailed survey of (1) Visible light communication system and characteristics of transmitter and receiver, (2) Modulation methods, (3) SISO, MIMO, MIMO-OFDM, (4) Visible light communication sensing and applications, (5) Visible light communication system architecture design and programming platform

Keywords- Visible Light Communication, Optical Fiber. MIMO.

I. INTRODUCTION

For a couple of years, the Light Emitting Diode (LED) has become a significant participant in the market of indoor and outdoor lighting uses. LEDs as a lighting technology offer several essential benefits concerning other lighting technologies, such as increased efficiency, high brightness, color selection without significantly discrediting productivity, etc. Another unique characteristic of LEDs concerning more standard lighting technologies is the larger bandwidth. This has opened the door for Visible Light Communication Systems (VLC), in which the fundamental role of lighting is combined with the creation of a wireless, optical communication system. A critical boundary condition is, of course, that the data communication system does not expose the lighting functionality. Due to the enormous bandwidth of LEDs, this condition can be met. Visible Light Communication (VLC is also known as Optical Wireless Communication OR Free-Space Optics) is a technology, which is a result of the union of Optical Communication and Wireless Communication. In this communication system, LED/Laser Diodes acts as the transmitter, and Photodiodes acts as the receiver, which is the same as that in optical communication. But instead of optical fibers, the natural atmosphere serves as the carrier. VLC can be used for wireless communications in certain areas where RF communications display poor achievement. The various merits of VLC over RF communication are like restricted transmission power, regulated spectrum, and also RF communication is forbidden in some areas. VLC offers an vast field of research and applications like position detection, smart, intelligent transport system, image sensor communication, networking, audio applications and aesthetics. In this paper, multiuser MIMO-OFDM (MU-MIMO-OFDM) is investigated for indoor VLC systems. Considering the distances of the multiple transmitter-receiver links are different, their temporal delays are also various, resulting in difficult channel gain and phase differences when converted to the frequency domain. The phase difference can not be neglected when wide-band systems are considered, especially for the subcarriers with high frequencies. Therefore, in our suggested scheme, the precoding matrix is calculated for each subcarrier in OFDM to eliminate multiuser interference. Different from state-of-the-art projects, sophisticated rather than real channel matrices can be used for precoding, which reduces the channel correlation with one more degree of freedom and improves the system performance.

Objective

In this work, we highlight the significance of implementing and investigating the different topologies of the visible light wireless optical transmission scheme. In this project we analyze the modulation scheme used as well as the advantages expected from the SiSo and MiSo topologies. We have examined the use of an analog modulation scheme, in our case OFDM , to increase the capability of the link and achieve high data rate figures. Spread spectrum systems offer substantial advantages to the wireless optical links which suffer from fading and the multipath effect humiliating their performance.

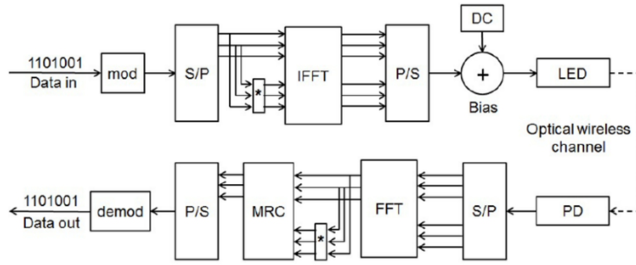

Figure 1. (a)LED Based Indoor Visible Light Communications Block Diagram

Some other techniques to incredulous these effects have introduced different transmission topologies than the standard SiSo used in most of the communication systems. In RF systems, multiple antennas (MiMo) have been verified capable of increasing throughput as well as removing the multipath and fading effects. This, in the realm of a wireless optical system, has to be explained to more than one transmitting components, Lasers or LEDs.

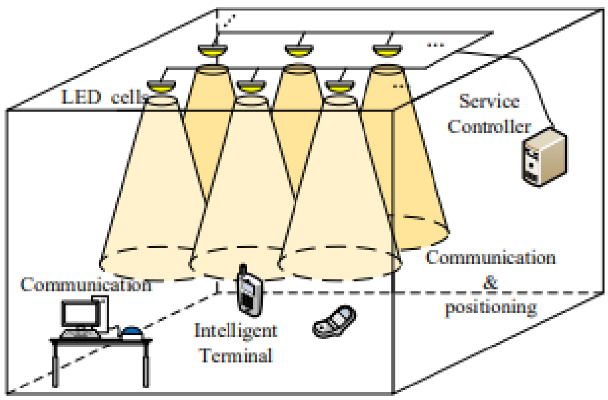

Figure 2: Structure of the proposed system

II. LITERATURE SURVEY

In recent years, visible light communication (VLC) has attracted increasing attention from both academia and industry since it has many advantages, such as wide unregulated bandwidth, high security, and low cost [1], [2]. It has been considered as a promising complementary technique to traditional radio frequency (RF) communications in fifth-generation (5G) and beyondwireless communications, especially in indoor applications [3], [4]. In indoor VLC systems, lightemitting diodes (LEDs) for illumination are used for data transmission at the same time, which is energy efficient. For low cost implementation, VLC systems typically utilize intensity modulation with direct detection (IM/DD), where the information is conveyed through the intensity of LEDs and detected by photodiodes (PDs) at the receiver.

Despite the fact that visible light spectrum is as wide as several terahertz, the bandwidth of offthe-shelf LED is limited, which makes it very challenging to achieve high data rate transmission [5]. Meanwhile, in order to provide sufficient illumination, multiple LED units are usually installed in a single room [6]. Therefore, multiple-input multiple-output (MIMO) techniques can be naturally employed in indoor VLC systems to boost the data rate, and various optical MIMO techniques have been investigated in [7]. Recently, multiuser MIMO (MU-MIMO) has been studied for VLC

systems and several precoding schemes have been proposed, which are different from conventional RF systems since only real-valued nonnegative signals can be transmitted [8]–[11]. In [8], the performances of zero forcing and dirty paper coding schemes are compared for indoor VLC broadcasting system. An optimal linear precoding transmitter is derived based on the minimum mean-squared error (MMSE) criterion in [9], while block diagonalization precoding algorithm is investigated in [10]. However, indoor VLC channels are typically highly correlated since there is no phase information and line-of-sight (LOS) scenario is mostly considered, which is unfavorable for the application of MIMO techniques and degrades the performance [12]. As a spectrally efficient modulation approach, optical orthogonal frequency-division multiplexing (OFDM) is intensively utilized in VLC systems and up to Gbps point-to-point data transmissions have been reported [13]–[17]. MIMO-OFDM is a popular technique in RF systems in order to support multiuser service and provide high data rate transmission [18], [19], however it has rarely been studied in VLC

systems. In [20], a MIMO-OFDM VLC system is demonstrated, but it requires an imaging diversity receiver to distinguish signals from different LEDs, which is infeasible for multiuser scenarios.

In this paper, multiuser MIMO-OFDM (MU-MIMO-OFDM) is investigated for indoor VLC systems. Considering the distances of the multiple transmitter-receiver links are different, their temporal delays are also different, resulting in complex channel gain and phase differences when transformed to the frequency domain. The phase difference can not be neglected when wide-band systems are considered, especially for the subcarriers with high frequencies. Therefore, in our proposed scheme, the precoding matrix is calculated for each subcarrier in OFDM to eliminate multiuser interference. Different from state-of-the-art schemes, complex rather than real channel matrices can be used for precoding, which reduces the channel correlation with one more degree of freedom and improves the system performance.

III. PROPOSED METHODOLOGY

Visible Light Communication (VLC) is a innovative kind of communication technology which is able to achieve high speed data transmission in indoor-communication. Thus, VLC attracts wide-ranging attentions worldwide. The optical

wavelengths of light is used as the carrier of information in VLC, and the Light Emitting Diodes (LEDs) emit high-speed flicker optical signals to transmit information, while the Photodetector (PD) or other optoelectronic transform devices receive the modulated optical signal and transform it to current signal. Compared to the traditional radio frequency communication and other optical communications, VLC has many advantages such as high transmitted power, non-electromagnetic interference, safety, and green. From what has discussed above, we can draw the conclusion that VLC has a great prospect for development [1]-[3]. The goal of indoor VLC is to achieve high speed data transmission [4], but the modulation bandwidth of white LED is just about 20 MHz [5], which is too limited to realize high speed data transmission in Single Input Single Output (SISO) system. When Multiple Input Multiple Output (MIMO) technique is applied in indoor VLC, it could possibly increase the scope of the communication link, overcome the interruption which is caused by personnel walks or shadows of the furniture in the room, and improve the reliability of the link. Meanwhile, the spectrum efficiency can be increased without the enhancement of bandwidth or transmit power [6], and the high data transmission will be achieved.

VLC BASED SYSTEM MODEL AND APROACES

The proposed system contains various stages as image acquisition, preprocessing, number plate localization, character segmentation, character recognition.VLC system has mainly three parts namely transmitter, receiver and channel. Every kind of light source can theoretically be used as transmitting device for VLC. However, some are better suited than others. The receiver consists of an optical element to collect and concentrate the radiation onto the receiver photo detector. This converts the radiation into photocurrent, which is then pre and post-amplified before data recovery. Receivers typically employ either long pass or band pass optical filters to attenuate ambient light. Long pass filters can be thought of as essentially passing light at all wavelengths beyond the cutoff wavelength. They are usually constructed of colored glass or plastic, so that their transmission characteristics are substantially independent of the angle of incidence. Long pass filters are used in almost all present commercial infrared systems.

SISO SYSTEM:

In the light communication system a SISO system, that is, the transmitter of the light communication system includes only one single light-emitting unit, and the receiver includes only one single photosensitive element.

MIMO SYSTEM:

The ideas of using multiple receive and multiple transmit antennas has emerged as one of the most significant technical breakthroughs in modern wireless communications. MIMO is the use of multiple antennas at both the transmitter and receiver to improve communication performance. MIMO technology has attracted attention in wireless communications, because it offers significant increases in data throughput and link range without requiring additional bandwidth or transmit power. This is achieved by higher spectral efficiency and link reliability or diversity.

OFDM

Orthogonal frequency-division multiplexing (OFDM), as one of realization of multiple-subcarrier modulation, provides parallel data transmission through transmitting orthogonal subcarriers between transmitter and receivers. OFDM systems can easily implement using Fast Fourier Transform (FFT), adapt to severe channel conditions not requiring complex time-domain equalization. Unlike PPM, they are not sensitive to time synchronization errors. Compared to other double sideband modulation schemes, OFDM techniques have high spectral efficiency, and are robust against narrow-band co-channel interference and inter symbol interference (ISI) along with fading caused by multipath propagation. Moreover, the techniques can adapt modulation to the quality of service (QoS) and the requested data rates of uplink/downlink (UL/DL). Also, any multiple access scheme can combine OFDM. Therefore, it is a good option to OW applications.

MIMO –OFDM FOR VLC SYSTEM

In existing SISO,MIMO VLC systems, single-carrier modulations are utilized with limited bandwidth [8]–[10]. Therefore, precoding is conducted in the time domain and only the DC channel gain in (1) is considered. Since the distances of the multiple transmitter-receiver links are different, their temporal delays are also different, resulting in complex channel gain and phase differences when transformed to the frequency domain. The time-domain channel responsefrom the qth LED unit to the pth user in (1) can be rewritten as

$$h_{p,q}(t) = h_{p,q}^{\mathrm{DC}}\delta\left(t - \frac{d_{p,q}}{c}\right)$$

Where $\delta(\cdot)$ denotes the Dirac delta function and c is the speed of light. Correspondingly, thefrequency-domain channel response for the kth subcarrier is given by

$$H_{p,q,k} = h_{p,q}^{\mathrm{DC}}\exp\left(-\frac{j2\pi kBd_{p,q}}{Nc}\right)$$

where B denotes the system bandwidth, and N is the size of fast Fourier transform (FFT). j isthe imaginary unit, and $j = \sqrt{-1}$.. It can be seen that the phase of the frequency-domain channelgain is proportional to the bandwidth. Moreover, when the temporal delay is considered, thefrequency-domain channel response is complex-valued, which provides an extra dimension andreduces the channel correlation with the phase differences of multiple links. However, in order
to achieve up to 100 Gbps high data rate transmission [21]–[23], wide bandwidth optical components are used, and the phase in the complex channel gain can not be neglected anymore.Therefore, MIMO-OFDM scheme is proposed for VLC system and precoding is performedon different frequencies individually.

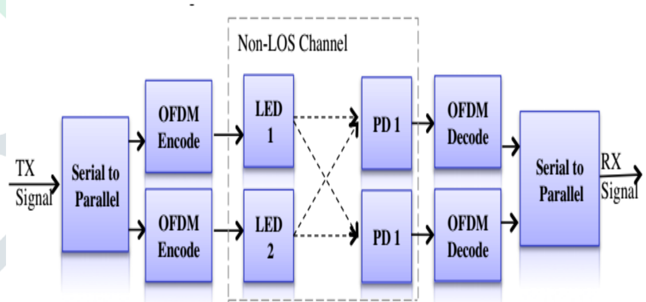

Figure 3. MIMO-OFDM System Model Using Spatial Diversity

IV. TEST AND IMPLEMENTATION

We implement our GUI model using Matlab, Where we study our input and output channel. In Our system we MIMO with OFDM is used. We study SISO also. We tested this system with different irradiance angle and space between lights. Every possible value of input have different estimated output with received power and channel gain. We show below our system gui model.

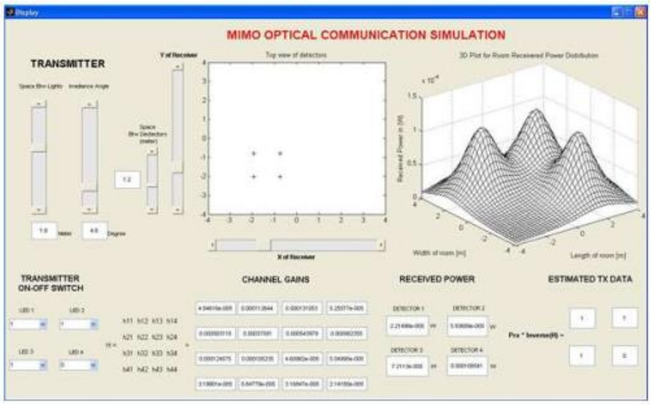

Figure 4: A gui model of MIMO and OFDM based Optical communication system

V. RESULT

We apply the different input in this system. We have four input transmitter on/off switch in our system. Which is control manually. After setting the space between lights and Irradiance angle of system we can be achieve the channel gains and the received power also with estimated output. We have many combination with input channel like as 1111,1010,0101,1001,0110,1000,0001,0100,0010.

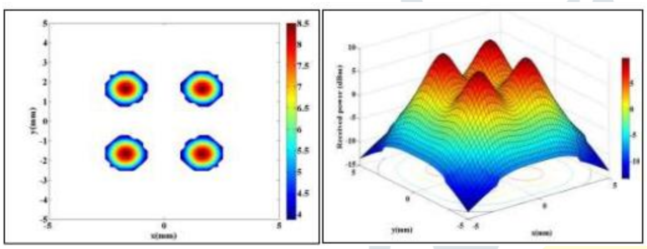

Figure 5: Power density at the imaging when FOV is 45^O

INPUT	LED	LED1	LED2	LED3	LED4
		1	1	1	1
CHANNEL GAINS	h11,h12,h13,h14	3.50487e-05	5.06296e-05	9.08812e-05	5.35194e-05
	h21,h22,h23,h24	5.06296e-05	3.50487e-05	5.35194e-05	9.08812e-05
	h31,h32,h33,h34	0.000129752	6.76848e-05	4.56863e-05	7.25032e-05
	h41,h42,h43,h44	6.76848e-05	0.000129752	7.25032e-05	4.56863e-05
RECEIVED POWER	DETECTOR	2.67535e-05	2.83115e-05	2.6259e-05	2.6259e-05
ESTIMATED OUTPUT DATA	Prx*Invere(H)	1	1	1	1

Table 1: Experimental results and analysis of system

VI. CONCLUSION AND DISCUSSION

In this paper, a different method is studied for VLC systems, MIMO-OFDM use in our approach, which considers the phase differences of channel environments in the light frequency domain induced by the distance differences between the various transmitter and receiver links. In this paper, we can design a signal surface using OFDM. And create a distance between surfaces. We also adjust the incident angle of the light beam, which enters an optical tube.

VII. ACKNOWLEDGEMENT

Expression of giving thanks is just a part of those feelings which are too large for words but shall remain as memories of beautiful people with whom I have got the pleasure of working during the completion of this work. I am grateful to Kalinga University Kotni Naya Raipur, Raipur, (C.G.), which helped me to complete my work by giving an encouraging environment. I want to express my deep and sincere gratitude to HOD (EEE) Dr. Sunil Kumar. His comprehensive knowledge and his logical way of thinking have been of great value to me. His understanding, encouragement, and personal guidance have provided a sound basis for the present work.

VIII. REFRENCES

[1]. Seigo Ito, et al. "High-Efficiency Organic-Dye-Sensitized Solar Cells Controlled by Nanocrystalline-TiO2 Electrode Thickness," Advanced Materials, vol. 18, no. 9, pp. 1202–1205, Apr. 2006.

[2]. Menyuk, N., K. Dwight, and J. W. Pierce. "NaYF4 : Yb, Er-an efficient upconversion phosphor," Applied Physics Letters, vol. 21, no. 4, pp. 159-161, Oct. 1972.

[3]. Muellermach, Regina, et al. "Nitridosilicates: a new family of phosphors for color conversion of LEDs," Proceedings of SPIE - The International Society for Optical Engineering, vol. 5941, pp. 59410Z-59410Z-8, Sep. 2005.

[4]. Xie, R. J, et al. "White light-emitting diodes (LEDs) using (oxy) nitride phosphors," Journal of Physics D Applied Physics, vol. 41, no. 14, pp. 2123-2131, Jul, 2008.

[5]. Rohit Saraf, et al. "Photoluminescence properties of Eu3+-activated CaMoO4 phosphors for WLEDs applications and its Judd–Ofelt analysis," Journal of Materials Science, vol. 50, no. 1, pp. 287-298, Sep, 2015.

[6]. L. Hanzo, H. Haas, S. Imre, D. O'Brien, M. Rupp, and L. Gyongyosi, "Wireless myths, realities, and futures: from 3G/4G to optical and quantum wireless," Proceedings of the IEEE , 100, pp. 1853 -1888, 2012.

[7]. Gyun-Tak Kim Doo-Hee Han Kye-San Lee Kyu-Jin Lee (2014), Analysis Performance of VLC System accordingto the Transmission Distance and Angle of Incidence, Journal of Convergence for Information Technology, Vol. 4, No. 4 pp.37-42

[8]. D.C.O' Brien et al,(2007) Visible Light Communication: state of the art and prospects published in Proc. Wireless World Research Forum 2007.

[9]. Xia Jun-bo (2014), Template matching algorithm based on gradient search IEEE International Conference on Mechatronics and Control (ICMC) Pages: 1472 – 1475

[10]. X. H. Ge et al, "5G Ultra-Dense CellularNetworks,". IEEE Wireless Communications, volume 23, issue 1, pp. 1536-1284, 2016.

[11]. L. F. Feng et al, "Applying VLC in 5G Networks: Architectures and Key Technologies,". IEEE Network, volume 30, issue 6, pp. 77-83, 2016.

[12]. Yong Jung ,Soo, et al.Lighting LEDs based Indoor Positioning System using ReceivedSignal Strength Ratio, Proceedings of 3DSA2013, P8-5.

[13]. Hu, Pan, Pharos: Enable Physical Analytics through Visible Light based IndoorLocalization

[14]. Walewski, S. Randel.et al Visible light communications: Challenges and possibilities.In PIMRC 2008, pages 1–5. IEEE, 2008

[15]. W. Zhang, M. S. Chowdhury, and M. Kavehrad, "Asynchronous indoor positioningsystem based on visible light communications," Optical Engineering, vol. 53, no. 4, pp. 045 105–045 105, 2014.

[16]. C. Chen, W.-D. Zhong, and D. Wu, "On the coverage of multipleinput multiple-output visible light communications [Invited]," IEEE/OSA J. Opt.

Commun. Netw., vol. 9, no. 9, pp. D31–D41, Sep. 2017.

[17]. B. Lin, Z. Ghassemlooy, X. Tang, Y. Li, and M. Zhang, "Experimental demonstration of optical MIMO NOMA-VLC with single carrier transmission," Opt. Commun., vol. 402, pp. 52–55, Nov. 2017.

[18]. Z. Ding, F. Adachi, and H. V. Poor, "The application of MIMO to nonorthogonal multiple access," IEEE Trans. Wireless Commun., vol. 15, no. 1, pp. 537–552, Jan. 2016.

[19]. Z. Ding, R. Schober, and H. V. Poor, "A general MIMO framework for NOMA downlink and uplink transmission based on signal alignment," IEEE Trans. Wireless Commun., vol. 15, no. 6, pp. 4438–4454, Jun. 2016.