An Implementation of Matlab based Platform for the Evaluation of Modulation Techniques using Multiuser MIMO-OFDM for Visible Light Communications using Matlab

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Abstract

Visible light communication is innovative and active technique in modern digital wireless communication. In this paper, we describe a new innovative vlc system which having a better performance and efficiency to other previous system. Visible light communication (VLC) is an efficient technology in order to the improve the speed and the robustness of the communication link in indoor optical wireless communication system. In order to achieve high data rate in communication for VLC system, multiple input multiple output (MIMO) with OFDM is a feasible option. However, the contemporary MIMO with OFDM VLC system are lacks from the diversity and the experiences performance variation through different optical channels. This is mostly because of characteristics of optical elements used for making the receiver. In this paper, we analyze the imaging diversity in MIMO with OFDM VLC system. Simulation results are shown diversity achieved in the different cases.

Keywords: multiple-input multiple-output (MIMO), multiuser, orthogonal frequency-division multiplexing (OFDM), precoding, Visible light communication (VLC)

I. INTRODUCTION

Since a couple of years, the Light Emitting Diode (LED) has become a major player in the market of indoor and outdoor lighting applications. Optical wireless communication technology precedes radio frequency (RF) technology by quite a long time but wireless communication using visible light spectrum was invented only a decade ago. Now, visible light communication (VLC) is being touted as a next generation optical wireless communication system [1], [2]. Optical communication using light emitting diodes (LEDs) facilitates the use of huge unexploited and unregulated bandwidth lies within a few hundreds of tetrahertz (THz) range, which inevitably solves the increasing spectrum demand. It is indeed a major breakthrough technology for both the wireless community and the connected devices domain. By installing a VLC transceiver into objects or devices can be connected to the internet. It can provide ubiquitous high speed wireless communication with comparatively less interference. It is envisaged that in future heterogeneous networks, visible light will coexist with RF counterpart [3],[4]. An optical wireless link can hugely be benefitted from high signal-to-noise ratio stemming from the illumination of the lighting infrastructure. Therefore optical access points (OAPs) should provide robust and high speed links to user. By implementing multiple input and multiple output (MIMO) technique along with orthogonal frequency division multiplexing (OFDM) into VLC will not only bring robustness in wireless data communication but also provide high data rate to users.

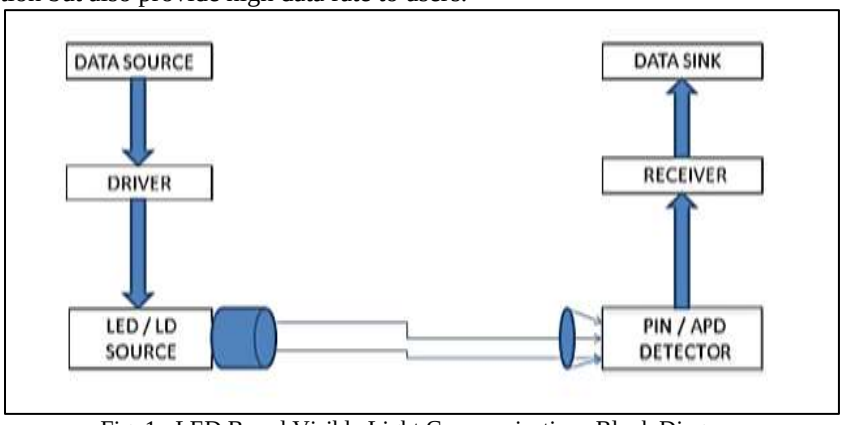

Fig. 1: LED Based Visible Light Communications Block Diagram

II. OBJECTIVE

In this work, develop a channel with MIMO and OFDM based visible light communication. In our previous paper we already describe and investigate the many previous technique for optical wireless communication. In this paper, we implement a gui model to control the gain of channel using the irradiance angle and space between light of visible light communication under the MIMO with OFDM techniques.

III. REVIEW WORK

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 beyond wireless communications, especially in indoor applications [3], [4]. In indoor VLC systems, light emitting 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 off the-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 cannot 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.

A. Visible Light Communication

Visible Light Communication (VLC) is a novel kind of communication technology which is able to achieve high speed data transmission in indoor communication. Thus, VLC attracts extensive 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. 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 potentially 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.

IV. 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

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

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

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

where B denotes the system bandwidth, and N is the size of fast Fourier transform (FFT). j is the imaginary unit, and $j = \sqrt{-1}$. It can be seen that the phase of the frequency-domain channel gain is proportional to the bandwidth. Moreover, when the temporal delay is considered, the frequency-domain channel response is complex-valued, which provides an extra dimension and reduces 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 cannot be neglected anymore. Therefore, MIMO-OFDM scheme is proposed for VLC system and precoding is performed on different frequencies individually.

V. 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.

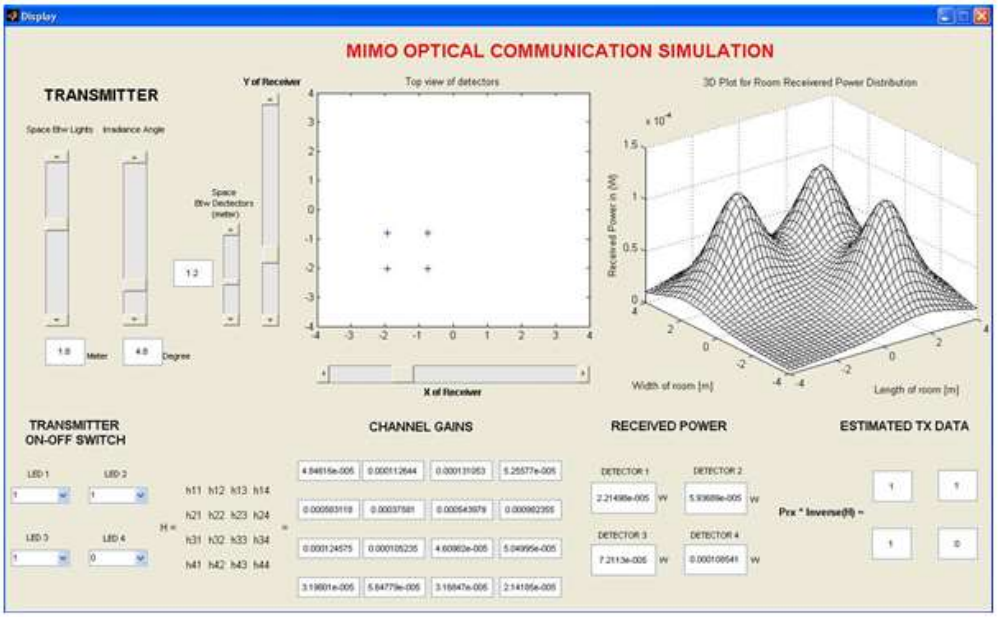

Fig. 2: A gui model of MIMO and OFDM based Optical communication system

VI. EXPERIMENTAL RESULTS

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.

Table – 1
Experimental results and analysis of system

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*

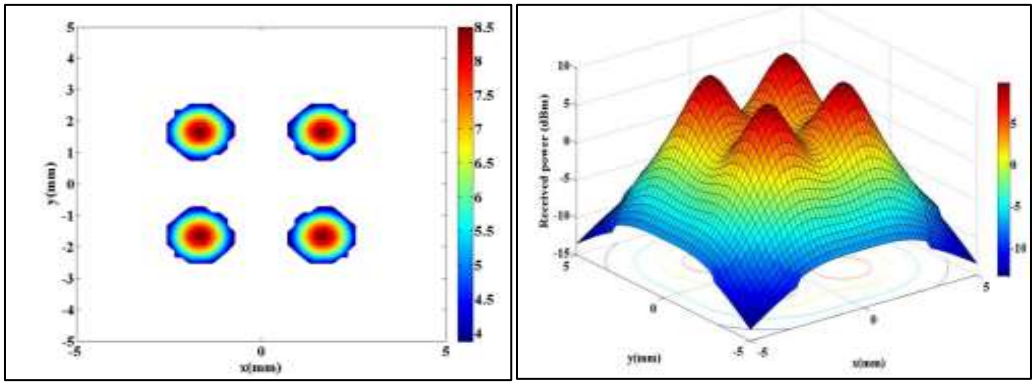

Fig. 3: Power density at the imaging when FOV is 45^{O}

VII. CONCLUSION

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

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