International Journal of Electrical and Computing Engineering
Vol. 1, Issue. 1, July – 2014 ISSN (Online): 2349-8218

Mitigating Effect of Flickering & Dimming in Visible Light Communication Using MIMO

A. Suban [1], P. Prabu [2] , R. Manikandan [3] , M. Pradeep [4]
Assistant professor, Dept of ECE, Velammal College of Engineering and Technology, Madurai
[2]PG student, Dept of CSE, Indian Institute of Information Technology, Trichy
[3] Project Engineer, WIPRO Lmited, Chennai, [4] Lecturer, Nagasiva Polytechnique College

***Abstract*— Visible Light Communication (VLC) refers to short-range optical wireless communication using visible light spectrum from 380 to 780nm and it has many advantages such as it can provide a maximum speed of 10GB/S. The other advancement is that the bandwidth available for visible light communication is 300THz whereas it is below 6GHz on RF communication. The transmission of data in VLC is done with the intensity modulating optical source, such as light emitting diodes (LEDs) because of its energy efficiency and recent advancement in LED technology with fast nanoseconds switching time. This paper applies OPPM (Overlapping Pulse Position Modulation) to provide higher data rate during its transmission of digital data when we compared to other modulation techniques. The result shows that the best performance can be obtained using OPPM, making it an ideal modulation technique for future visible light communication. MATLAB and Lab View are the two methodologies we used for simulation purpose. Moreover Multiple Input Multiple Output (MIMO) techniques is potentially adopted for achieving high data rates. MATLAB Simulations are carried out and depicted.**

***Index Terms*— Visible light, White LED, On Off Keying, Variable Pulse Modulation, Overlapping Pulse Position Modulation.**

I. INTRODUCTION

In the development of wireless communication system when the third generation mobile communication system is employed, manufacturers and the scientific group are increasingly turning their research interest towards future wireless communication system because traditional radio frequency (RF) communication below 6 GHz is rapidly running out of spectrum bandwidth for high data-rate communication. Visible Light Communication has recently been developed by scientists seeking to create an ultra-high speed, high security, biologically friendly communication networks that allow the creation and expansion of continuous computing applications using very large bandwidth high-frequency pulsed light instead of radio waves and microwaves. Visible Light Communication (VLC) is the short-range optical wireless communication using the visible light spectrum from 380 to 780nm. With ~300 THz of bandwidth available for VLC, multi-gigabit-per second data rates could be provided over short distances.

This wide spread of bandwidth removes one of the major difficulties faced by new communication schemes. Some of the noted advantages of visible light communication over RF (Radio Frequency) and IR (Infra-Red) based systems are:

- Higher security than RF communication system.
- No restriction on transmission power unlike in IR communication system.
- No regulations in the use of the visible electromagnetic spectrum.
- The key advantage of VLC is the duality in the use of the visible light. The same light that is used for the communication can also be used for illumination applications such as domestic light bulbs, LED TVs, and traffic lights.

In an optical communication system, there is a possibility of modulating the transmitted optical signal in a variety of ways. The phase, frequency and the intensity of the optical signal can be modulated. VLC transmits data by the intensity modulating optical sources, such as light emitting diodes (LEDs) and laser diodes, because it is easy to implement and the optical output power is simply changed in accordance with the modulating signal. There has been renewed interest in visible light optical communication due to widespread deployment of LEDs for energy efficiency and recent advancements in LED technology with fast nanosecond switching times.

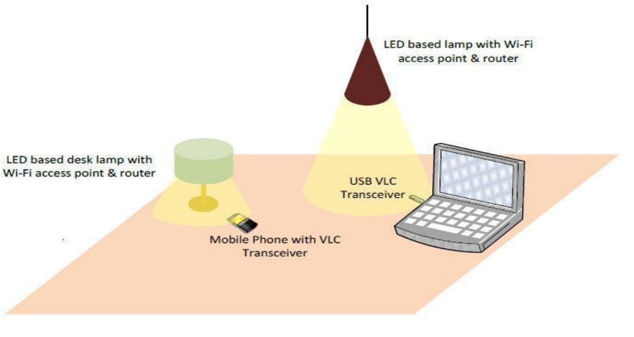

Figure 1. An Alternate Technology-VLC

Suban. A, *Electronics & Communication Engineering, Velammal College of Engineering and Technology, Madurai*

Prabu.P, *Computer Sceince & Engineering, Indian Institute of Information Technology*

Manikandan.R, *Project Enineer, WIPRO Limited, Chennai.*

Pradeep.M, *Electrical & Electronics Engineering, Nagasiva Polytechnique College, Madurai*

LED VISIBLE LIGHT COMMUNICATION

In this 21st century, LEDs are extensively used in various electronic devices, consumer products and due to their small size they are preferred for illuminating technologies. Recently experiments have shown that advance in semiconductor material and manufacturing techniques of LED is to be suitable for general indoor and outdoor applications. In addition to that LED produces less heat than other fluorescent and incandescent light bulbs. In the industry side, LEDs are referred as "cool lights" and most sustainable in light technology. Low cost

LED instead of lasers can be used as communication transmitters connected to the electric grid, receiving high-bit rate signals. So LED (Light Emitting Diode) Visible Light Communication systems are recognized as creating a possible valuable addition to future generation of technology, which have the potential of using light for the purpose of advanced technological communication at ultra-high speed surpassing that of current wireless systems. If it is developed correctly, the possibility exists than many of the problems associated with present day infrared, Bluetooth and radio wave could be at least partially resolved, and industries and the general public can gain a more biologically friendly system. The main reasons for using LED are followed:

- High usage of bandwidth.
- Existing local power line infrastructure can potentially be utilized.
- Very simple transmitter and receiver circuit and it is not expensive.
- Eco-friendly.
- Long life expectancy.

A further advantage is that VLC systems can transmit data more securely over short distances than other communication devices whose signals can be easily detected outside the rooms and buildings they originate in. In the following section, the paper describes the system design for the visible light communication, modulation method and their benefits for flickering.

III. SYSTEM DESIGN

A typical Visible Light Communication system contains two parts namely transmitter module and receiver module. VLC system appears in the form of point to multi-points which permits data transmission in one direction only. The following figure shows the overall VLC system block diagram. The receiver occupant may realize information uplink with extra optical devices, and more sophisticated the duplex system is the duplex system.

A. TRANSMITTER MODULE

In the transmitter module, the Light Emitting Diode is used to transmit the data and it has to be designed in such way that power and the colour temperature both safe and comfortable for human eyes.

when the same LED is used for illumination because it won't make people feel uncomfortable and dizzy. It's important to note that the receiver occupant may block the light beam and put the receiver in shadows, so more than two LED lamps should be modulated simultaneously from various directions to cover a larger recipient area. In some case where the receiver loses connection with the transmitter, it will be able to receive data from another transmitter instantaneously.

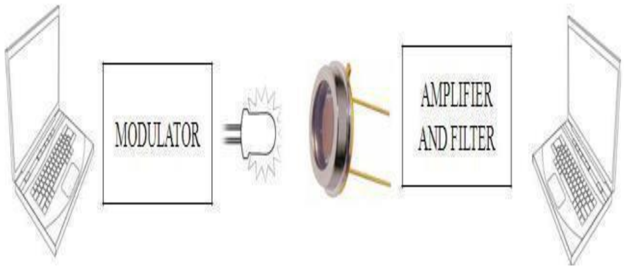

Figure 2. Visible Light Communication Transmitter and Receiver Block Diagram

B. RECEIVER MODULE

A receiver module is mostly composed of PIN detectors and signal conditioning devices. The output signal from the detector is weak with a lot of background light noise and a long free space communication distance only makes the situation worse. Therefore, the critical part of our VLC system is the signal conditioning circuit .

The receiver's PIN photo detector is connected to a trans-impedance amplifier to convert the current signal into a voltage signal. A high pass filter is applied next to bypass the light noises and power line noises. Finally, the signal is amplified by a main amplifier and it is reshaped by comparator.

IV. MODULATION TECHNIQUE IN VLC

In the modulation process, the baseband signals constitute the modulating signal and the high-frequency carrier signal is a sinusoidal waveform or cosine waveform. The sine wave carrier can be normally modulated by three basic ways. For the modulation of binary digital data, the three modulation techniques used are binary amplitude-shift keying (BASK), binary frequency-shift keying (BFSK) and binary phase shift keying (BPSK).

A. AMPLITUDE SHIFT KEYING

Amplitude-shift keying (ASK) is a form of modulation technique that represents digital data as variations in the amplitude of a carrier wave. To transmit digital data over optical fibre ASK technique is normally used. For transmission using LED, binary 1 is represented by a short pulse of light whereas absence of light represents binary 0. This process is said to On Off Keying (OOK).

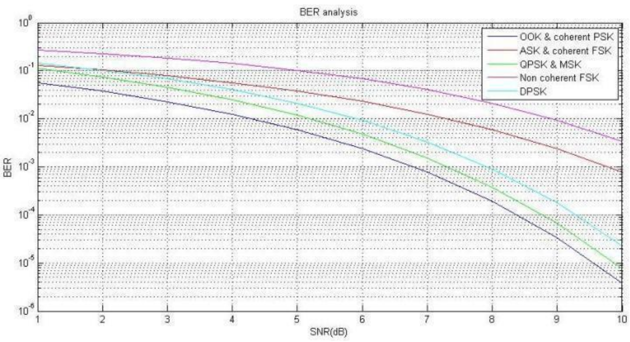

Figure 3. MATLAB simulation of Bit Error Rate for various modulation methods

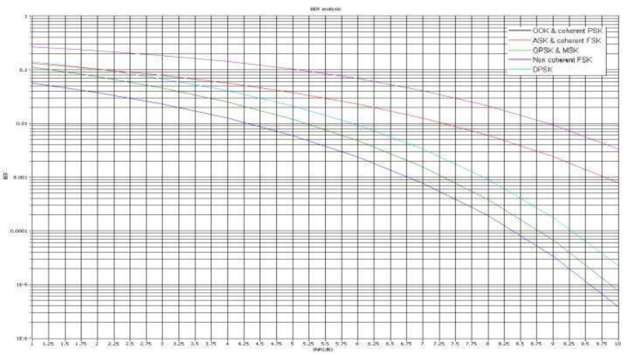

Figure 4. Lab View simulation of Bit Error Rate for various modulation methods

From the simulated results, the following conclusions are made. The error rate for all the modulation techniques decreases monotonically with increasing value of SNR. For any given value of SNR, coherent PSK & OOK produces same and smaller error rate than any of the other modulation technique. So, coherent PSK and OOK are the optimum system for transmitting binary data because it achieves the minimum probability of symbol error for the given value of SNR. But considering OOK and coherent PSK, OOK is the best and most efficient modulation technique in terms of bandwidth and power consumption. DPSK require an SNR that is 3 dB less than that of coherent FSK and noncoherent FSK to achieve same error rate. For higher values of SNR, DPSK and noncoherent FSK performs almost as well as coherent PSK and coherent FSK. For higher values of SNR, coherent PSK and QPSK have same error rate performance. Also it has been inferred that MSK has exactly the same error performance as that of QPSK.

B. Variable Pulse Position Modulation

Pulse position modulation (PPM) encodes the data using the position of the pulse within a set time period. The duration of the period containing the pulse must be long enough to allow different positions to be identified.

C. OVERLAPPING PULSE POSITION MODULATION

Although VPM can provide data rates in terms of few hundred megabits/s but even higher data rate than the existing one is not possible due to its inherent throughput limitations. Reducing the pulse width is the one and only way to increase the throughput of the VPM. So there is a need for some other modulation methods to provide higher data rate but that should not have the limitations as with that of VPM. OPPM is one of the promising modulation scheme that allows more than one pulse per pulse width and it has some of the useful properties such as equal energy signals and low duty cycle.

Figure 5. MATLAB simulation of Data rate Vs Duty cycle for OOK & OPPM

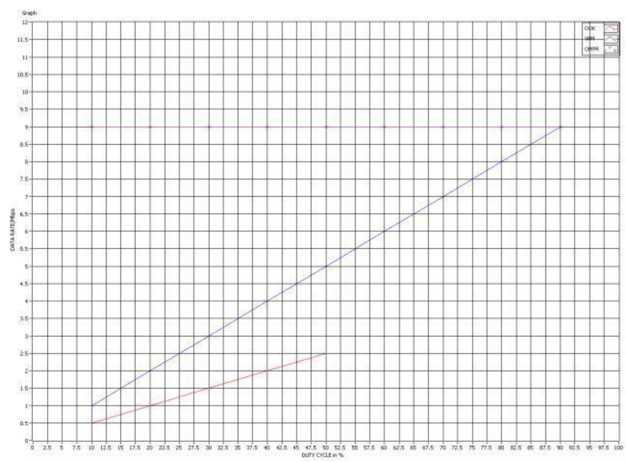

Figure 6. Lab View simulation of Data rate Vs Duty cycle for OOK & OPPM

From the simulated results, the following conclusions are made. We can see that the OPPM signal has the best flicker performance, followed by VPM and OOK.

The flicker severity value is 0.525 for any dimming levels, which is far less than the limited value. We can also notice that the 90% duty cycle VPM signal has the same flicker performance as OPPM. But the flicker severity of OPPM signal is invariant with changing different dimming levels.

D. MULTI-ANTENNA CONFIGURATION

Solid-state lighting is a rapidly growing area of research and applications, due to the reliability and predicted high efficiency of these devices. The white LED sources that are typically used for general illumination can also be used for data transmission, and Visible Light Communications (VLC) is a rapidly growing area of research. One of the key challenges is the limited modulation bandwidth of sources, typically several MHz However, as a room or coverage space would typically be illuminated by an array of LEDs there is the potential for parallel data transmission, and using optical MIMO techniques is potentially attractive for achieving high data rates. In this paper we investigate non-imaging and imaging MIMO approaches: a non-imaging optical MIMO system does not perform properly at all receiver positions due to symmetry, but an imaging based system can operate under all foreseeable circumstances. Simulations show such systems can operate at several hundred Mbit/s and up to Gbit/s in many circumstances.

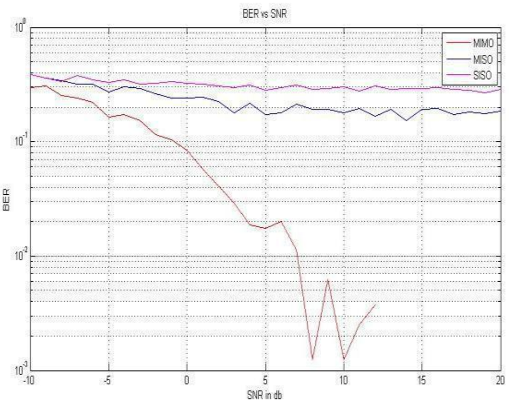

Figure 6. MATLAB simulation of Bit Error Rate (BER) Vs Signal to Noise Ratio (SNR) for various systems such as SISO, MISO and MIMO using OPPM Technique

From the simulated results,it can be inferred that using SISO system model i.e. using single LED in the transmitter side and a single photodiode or LED in the receiver side we have very large bit error rate for increase in SNR for given input. In the next case of MISO,i.e. using two LED transmitter side at the transmitter side and a single LED or photodiode at the receiver side we achieve the bit error rate smaller than SISO system but not smaller than MIMO system. In the next case of MIMO system,i.e.using arrays of LED at the transmitter side and arrays of LED or photodiode at the receiver side we get a very smaller BER when we compared to SISO and MISO system and it proved that VLC is adaptable for MIMO configuration and it give best results when we compared to all other system configurations.

Following assumptions are made for the simulated results

Channel: AWGN

Modulation technique used: OPPM
ANTENNA SIZE: 2*2 for MIMO
1*1 for SISO
2*1 for MISO

V. DISCUSSIONS

We analysed the Performances of OOK and OPPM signals by investigating the cutoff data rate and Bit Error Rate analysis of various modulation techniques. We proved that OPPM signal has the smallest and constant flicker severity under all dimming levels spanning a reasonably large brightness dimming range. This modulation scheme also provided the largest and steady cutoff data rate. OPPM appears as the desirable modulation solution to emerging LED-based high capacity visible light communication.

VI. REFERENCES

[1] Bluetooth SIG, Inc. (2009), Bluetooth Basics [Online], Available: http://www.bluetooth.com/Bluetooth/Technology/Basics.htm

[2] IrDA, (2009). IrDA Background. IrDA [Online]. Available: http://www.irda.org/

[3] T.Komine and M.Nakagawa, "Fundamental analysis for visible light communication systems using LED Lights," IEEE Trans. Consumer Electronics, vol. 59, no. 1, Feb, 2004, pp. 1000-07.

[4] M. Kavehrad, "Sustainable Energy Efficient Wireless Applications Using Light," IEEE Commun. Mag., vol. 48, no. 12, Dec. 2010, pp. 66-73.

[5] P. Amirshahi, M. Kavehrad, "Broadband Access over Medium and Low Voltage Powerlines and use of White Light Emitting Diodes for Indoor Communications," IEEE Consumer Communications & Networking Conference, Las Vegas, Nevada, January 2006.

[6]L.Zeal et *al.* ,"High Data Rate Multiple Input Multiple Output (MIMO) Optical Wireless Communications Using White LED Lighting," *IEEE ISAC* , vol. 27,no.9,Dec.2009,pp. 1654-62.

[7]M.Kahn and J.R.Barry,"Wireless Infrared Communications,"*Proc. IEEE,* vol.85, no.2, 1997, pp.265-98.

[8]G.Pang, T.Kwan, H.Liu, C. -H.Chan,"LED Wireless: A Novel use of LEDs to transmit audio and digital signals", IEEE Industry Applications Magazine, Vol.8, January 2002.

[9]J.K.Kwon,"Inverse Source Coding for Dimming in Visible Light Communications Using NRZ-OOK on Reliable Links",IEEE Trans.photon.technol.Lett.,vol.22,no.19,pg.1455-1457,Oct 2010.

[10] H.Sugiyama, S.Haruyama, and M.Nakagawa, “Experimental investigation of modulation method for visible-light communications,”*IEICE Trans. Commun.*, vol.E89-B, no.12, pp.3393-3400, Dec.200

[11] O ‟ Brien and Marcos Katz, “Short-Range Optical Wireless Communications”, Wireless World Research Forum(WWRF11), Oslo, (July 2004)

[12] T.D.C. Little, P. Dib, K. Shah, N. Barraford, and B. Gallagher, “Using LED Lighting for Ubiquitous Indoor Wireless Networking”, IEEE International Conference on Wireless & Mobile Computing, Networking & Communication, DOI 10.1109/WiMob.2008.57, 373-378(2008)

[13] D. C. O‟Brien, “Indoor optical wireless communications: recent developments and future challenges,” in Free-Space Laser Communications IX, San Diego, CA, USA, 2009, pp. 74640B-12

[14] G. Pang, C.H. Chan, H. Liu, and T. Kwan. (1998). „Dual use of LEDs: Signalling and communications in ITS,” in 5th World Congr. Intelligent Transport Syst. [CD-ROM]. Paper 3035.

[15] M.G. Craford, “LEDs challenge the incandescents,” IEEE Circuits Devices Mag., vol. 8, pp. 24-29, Sept. 1992.

[16] J. Grubor et al., “Bandwidth Efficient Indoor Optical Wireless Communications with White Light Emitting Diodes,” Proc. 6th Int ‟l. Symp. Commun. Sys., Networks and Digital Signal Proc., vol. 1, Graz, Austria, 23–25 July 2008, pp. 165–69.

[17] Y. Tanaka et al., “Indoor Visible Light Data Transmission System Utilizing White LED Lights,” IEICE Trans. Commun., vol. E86-B, no. 8, Aug. 2003, pp. 2440–54.

[18] T. Komine, M. Nakagawa, “A Study of Shadowing on Indoor Visible-Light Wireless Communication Utilizing Plural White LED Lightings,” Int. Sympo. On Wireless Commun., pp. 36-40, 2004.

[19] M.Z. Afgani, H. Haas, H. Elgala, D. Knipp, “Visible light communication using OFDM,” Proc. IEEE Symp. on Wireless Pervasive Computing, TRIDENTCOM 2006.

[20] IEEE 802.15.7 Draft D8, “Standard for Short-Range Wireless Optical Communication using Visible Light”, 2011