International Journal of Research Studies in Science, Engineering and Technology
Volume 5, Issue 11, 2018, PP 1-6
ISSN : 2349-476X

Distance Estimation Using 8-PPM for V2V Visible Light Communication Using

[1]Mohammed Musa, [2]Hongbing Qiu

[1]Communication department, institute of information and communication, Guilin university of electronics technology, Guilin , China
[2]University of Bahri, Khartoum, Sudan.

***Corresponding Author:** Mohammed Musa, Communication department, institute of information and communication, Guilin university of electronics technology, Guilin , China*

ABSTRACT

With the increase in vehicles on the road, accidents are increasing, so the challenge facing researchers is how to provide safe roads allow vehicles to maintain people's lives. V2V based VLC Is one of the solutions to this dilemma, which provides the process of fast and safe connection between the vehicles. in this paper we proposed mathematical model for vehicle to vehicle to vehicle visible light communication that indent to predict the system performance under different modulation techniques, and the road-surface reflection model are employed. low beam for headlamp and tail lamp of two vehicles are consider as transmitter and photo-detector respectively. We consider both the line-of-sight and non-line-of-sight links and outline the relationship between the communication range and the system bit error rate (BER) performance, and outline the relationship between the communication distance, the system bit error rate (BER) performance of both on-off keying and 8-pulse position modulation are studied . Results show that the receiver height at 0.8 m in vehicle above the surface of the road can give data communication up to 20 m with BER of 10^{-4} which is better result compare to our paper reference.

Keywords: *LED based VLC, V2V based VLC, 8PPM.*

INTRODUCTION

With the explosion of wireless communication services and spectrum crises due to heavy demand of the traffic of data leads to high energy consumption and bandwidth exhausted [1, 2], an alternative method of communication of wireless communication using visual light is visible light communication [3, 4] was proposed as a new wireless communications technology is strongly required to meet this challenge. Furthermore, VLC is considered as energy efficient wireless communication solutions to be deployed in 5G wireless systems. VLC technology has twofold use in transmission environments indoor and outdoor technology [5].

The outdoor VLC environment used to offer services which can be applied in several applications. It provide a communication between buildings, vehicles, and facilitates the use of street and park lights to render communication. It may also facilitate the task of self-driving vehicles and allows traffic lights to become VLC transmitters. The outdoor VLC environment also enables the use of solar panels to harvest energy and receive a communication signal [6].

Nowadays the demand for vehicles is getting increased which is leads to compound the numbers of accidents on the road. Furthermore, the number of road accidents committed by young people, represent the leading cause of mortality[7]. In contrast the traffic congestion due the huge number of car becoming an increasingly widespread problem. First, people may spend a longer commuting time between their home and workplace. Second, air and noise pollution will increase, severely threatening the health of urban populations. Fuel consumption has also dramatically increased, contributing greatly to the amount of CO_2 emissions adding to global warming [8].

VLC technology applied on V2V communication was used to overcome all these challenges and offer best solution leads to increase the safety and provide high efficiency of road transportation, prevent intersection crashes and rapidly propagate accident reports. For example, VLC technology shares the information between the vehicles and road's infrastructure and among the vehicles, improve the traffic flow and reducing the congestion, and address environmental concerns by monitoring driving behavior, thus giving warnings to drivers and even control and stop of the vehicles providing information for safe driving [9].

V2V based VLC provide magnificent advantages compare to V2V based RF, such as low cost due to usage of the existing LED lamps on the vehicles, and provides precise positioning in LOS characteristics of light which is reduce the error and improve the system performance[10].

Table I. *Comparison of VLC and RF (DSRC) schemes*

Type	VLC	RF (DSRC)
Communication Mode	LOS – Point-to-point	Broadcasting -Point-to multipoint
Target data rate	400 Mbps	27 Mbps
Carrier frequency	400-790 THz	5.85-5.925 GHz
Licensing	Free	Required
Mobility	Low - medium	High
Power efficiency	High	Medium
Coverage area	Low and narrow	Long and wide

LED play an important role in whole scenario, LED devices have benefits such as, energy savings, long life, low maintenance cost, better visibility and high brightness. Looking at these benefits, LEDs are replacing automobile brake lights and even head lights. Visible light communication (VLC) systems use the inherent characteristic of high rate switching as a means to convey information [11].

Recently, research based on the theoretical and experimental aspects of the VLC V2V has been steadily increasing. in this paper a mathematical model in different communication modulation techniques for V2V based VLC was studied and bit error rate performance for on the communication distance between two vehicles was investigated. The channel characterization of a traffic light to vehicle VLC system was studied an analytical LOS path loss model has been proposed and validated by measurement results. Both line-of-sight and non-line-of-sight links were considered. two vehicle's headlamp of the second vehicle consider as a transmitter and tail lamps of the first vehicle is consider as PD. traffic light to vehicle channel has been considered and studied.

In this paper, we carry out bit error rate (BER) performance analysis and evaluation for a V2V VLC using 8PPM. A market-weighted headlamp beam pattern model is employed and both the LOS and non-line-of-sight (NLOS) links configurations are incorporated into the model.

The remainder of the paper is organized as follows: In Section 2, we describe the system configuration, outline the mathematical model of luminous intensity and a transmitted optical power, and modulation techniques are also discussed in this section. Section 3 is reserved to noise analysis. In Section 4, The BER performances of our system, and simulation results, discussion are described in section 5. concluding remarks are provided in Section 6.

System Model

In this section, the V2V VLC system model is presented. In detail, we consider a market-weighted headlamp model, road surface Lambertian reflection model, optical channel model using 8 PPM modulation technique , and ambient noise model in our proposed, system model as in figure 1.

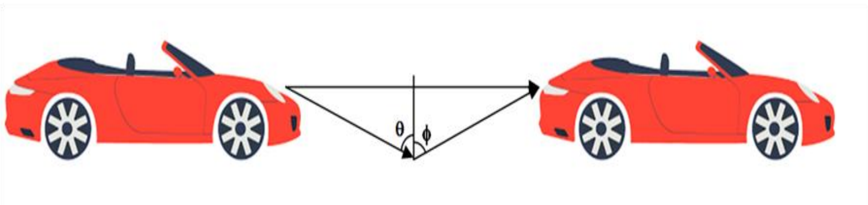

Figure 1. *V2V VLC communication link*

Fig. 1. as in [12] show the communication system headlamp as a transmitter of the left vehicle and the tail lamp of the right vehicle as receiver separated by VLC channel. Both direct light and reflected from road surface were combined as mathematically.

LED Light for LOS Properties

In light there are two properties, a luminous intensity and a transmitted optical power. The relationship between photometric and radiometric quantities is explained in [13], in this paper we concentrate on the luminance of low beam headlamps.

Illuminance of LED Lighting:

The Illuminance expresses the brightness of an illuminated surface, in this paper we study the distribution of illuminance at a daytime. The luminous intensity in angle:

$$I(\Phi) = I(0)\cos^{m}(\Phi) \quad (1)$$

A horizontal illumination E is given by

$$E = \frac{I(0)\cos(\psi)}{d^2} \quad (2)$$

Where m is Lambertian order assumed is 1 , I(0)is the center luminous intensity of an LED, Φ is the angle of irradiance with respect to the transmitter perpendicular axis, ψ is the angle of incidence related to the receiver perpendicular axis, d is the distance between the light source and the receiver.

Led Light Design For NLOS

In the fig. 1 in this research we assumed the refection is surface road reflection with reflection radiant intensity R(φ) as in [12] with the parameter mention the table II.

$$R(\emptyset) = \rho\frac{\cos\emptyset}{\pi} \quad (3)$$

where φ is the polar angle of the scattered light, and ρ is the diffuse reflectivity. Fig. 2 shows the configuration of C2C VLC system using LOS and NLOS models, the low beam batten on the road surface the design of the full system is come out as the double of the our which the photodetector (PD) receives light from both the right and left headlamps, and the modeling is done for right side of headlamp, the A horizontal illumination E with respect to road surface is given as

$$E = \frac{I(0)\sin(\psi)}{d_T{}^2} \quad (4)$$

Where d_T d is the distance between the light source and the road surface reflection point, In this paper , luminous efficacy of radiation (LER) assumed to be 250.3 lm/W [14].

The received power at the reflection point can be expressed as:

$$dP_f = \frac{I(0)\sin(\psi)}{LER.d_T^2}dS \quad (5)$$

Received light power intesity in the tail lamp (PD) of desitation vehicle from reflected point can be expressed as:

$$dP_r = \frac{dP_f.R(\emptyset).A_r.\cos(\psi)}{(d^2+h^2)} \quad (6)$$

where Ar is the area of the PD, and d is the distance form reflection point to the PD, h is the height of the PD.

The total receive power at the receiver is the summation of the direct and reflect power with the range of field of view (FOV) and the whole illuminated area S. the equations 7 and 8 illustrated PrNLOS and PrLOS respectively.

$$P_{rNLOS} = \begin{cases} \iint_s P_{rNLOS}\, dS & 0 \le \psi \le \Psi \\ 0 & \psi > \Psi \end{cases} \quad (7)$$

where Ψ is the half angle of PD's field of view (FOV) and Sis the entire area of road surface that has been illuminated.

$$P_{rLOS} = \begin{cases} \frac{I(0_B)A_r\cos(\psi_B)}{LER.d_B^2} & 0 \le \psi_B \le \Psi \\ 0 & \psi_B > \Psi \end{cases} \quad (8)$$

where the ψ_B is the angle between incident LOS light to PD, and $I(0_B)$ is the luminous intensity. the total received power of both sides can expressed as:

$$P_R = P_{rLOS} + P_{rNLOS} \quad (9)$$

where P_R is total received power at PD receiver.

Modulation Techniques

They are a part of communication process in communication system which is better performance of the system in based on appropriate and robust modulation techniques. Different modulation schemes have been studied as well in this paper[15].

On-Off keying OOK

In OOK, the LEDs are turned off and on based on the bits in the stream. Moreover, during an OOK transmission, an optical pulse which occupies part of entire bit duration represents a single data bit "1". On the other hand, the absence of an optical pulse represents a single data bit "0". The ratio of on-off signal of OOK changes the DC value of the OOK signal which would affect the stability of optical power transfer, OOK scheme does not guarantee the absence of flickering and has lower spectral efficiency. OFDM techniques offer both good *multipath and narrowband interference rejection response, but imply quite expensive hardware requirements. In this research we consider MPPM scheme which it is characterized by having a better system performance against AWGN channel[16].*

$$\boldsymbol{BER_{OOK}} = \boldsymbol{Q}\left(\sqrt{\boldsymbol{SNR}}\right) \quad (10)$$

Pulse-Position Modulation (MPPM)

MPPM is a modulation technique for simultaneous communication and dimming. the magnificent advantages of PPM scheme is the elimination of decision threshold dependence on the input power [17]. MPPM is log2(M) equiprobable input bits form a time domain symbol. It is a sequence of M chip represented as a vector, instead of allowing for one pulse per symbol period in one of M chips, it permits multiple pulses in any of the M chips. MPPM scheme and bit rate and BER can be expressed as follows [18]

$$R_b = B\frac{\log_2 M}{M} \quad (11)$$

$$BER_{PPM} = \frac{1}{2} Q\left(\frac{1}{2\sqrt{2}}\sqrt{SNR\frac{M}{2}\log_2}\right) \quad (12)$$

Noise Analysis

There are two types of noise affecting the light's path in an outdoor VLC, which are background solar radiation which is composed of direct sunlight and scattered radiations from surrounding surfaces during the daytime, and ambient light coming from vehicles, traffic light, and street light during the nighttime. Noise on daytime is stronger than at nighttime, therefore, the direct radiations are considered as the dominant noise component. Note that the intensity of the solar radiation received at the earth surface depends on the atmospheric conditions and the position of the sun both during the day and throughout the year [19]. according to [20] the shot noise introduced by solar radiation is consider the main noise for V2V based VLC system in the daytime, and noise comes from ambient light consider the main noise at nighttime. In this paper we consider the total noise affecting our system as the additive white Gaussian noise AWGN with a mean of 0 and variance of σ^2 illustrated as:

$$\sigma^2{}_{total} = \sigma^2{}_{shot} + \sigma^2{}_{thermal} \quad (13)$$

$$\sigma^2{}_{shot} = 2eRP_rB + 2eI_{bg}I_2B \quad (14)$$

$$\sigma^2{}_{thermal} = \frac{8\pi k T_k}{G}\eta A_r I_2 B^2 + \frac{16\pi k T_k \Gamma}{g_m} A_r^2 \eta^2 I_3 B^3 \quad (15)$$

where, R is the responsively of the PD, e is the electronic charge (1.602×10^{-19} C), B is the system bandwidth, Pr is the average received optical power of the desired signal, Ibg is the received background noise current, I_2 is the noise bandwidth factor for the background noise[12], k is Boltzmann's constant, T_K is absolute temperature, G is the open-loop voltage gain, η is the fixed capacitance of PD per unit area, Γ is the field-effect transistor (FET) channel noise factor, g_m is the FET trans-conductance, A_r is the detection area of the PD, and the noise bandwidth factor I_3 = 0.0868[21].

BER Performance of A V2V VLC System

In this section, a 8PPM modulation technique for a C2C VLC system is developed and its BER performance is simulated. Also outlined is the relationship between the transmission distance and BER. According to [16], for a V2V VLC link the typical channel delay is 10ns, compared to few MHz bandwidth used in a VLC system, therefore ISI is not considered in our model.

OOK and 8PPM modulation scheme under AWGN channel were investigated. as well as other parameters listed in Table II.

Table I1. *System parameters*

Parameters	value
Diffuses reflectivity	0.4 [28]
PD area	1 (cm2)
Order of Lambertian diffuser	1
Luminous efficacy of radiation	250.3 (lm/W)
FOV of the PD	60º
Electronic charge	1.6×10-19 (C)
Responsivity of PD	0.54 (A/W)
Received background noise current	5100 (μA)
Noise bandwidth factor	0.562
Boltzmann's constant	1.38×10-23 (J/K)
Absolute temperature	298 (K)

Open-loop voltage gain	10
Fixed capacitance of PD per unit area	112 (pF/cm2)
FET channel noise factor	1.5
FET transconductance	30 (mS)
System bandwidth	2 (MHz)
Luminous intensity (cd)	10

Simulation Result And Discussion

In our simulation Matlab software has been used. All parameters are listed in table II, we have adopted the optical channel configuration as shown in Fig. 2, low beam lamps (75 % luminous intensity) for the daytime, concrete road surface. BER performance of the V2V based VLC using OOK and 8PPM modulation techniques at data rate of 2 Mbps with fixed the height of PD and comparison has been investigated. In Fig. 3 the BER performance of OOK scheme slowly increased with increasing of the distance up to 10 m only, after that its gave fix value at different values of the distance between the transmitter and receiver. Fig. 4 show the BER performance of the system when an OOK modulation scheme was investigated, we consider BER of $10e^{-4}$ as threshold and got the distance between two vehicles is 2.6 m, when the distance is increased the BER decrease simultaneously.

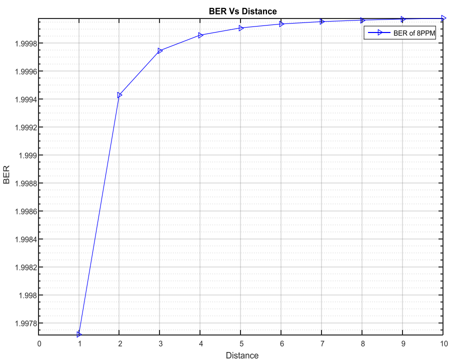

Figure 3. *BER performance between two vehicles.*

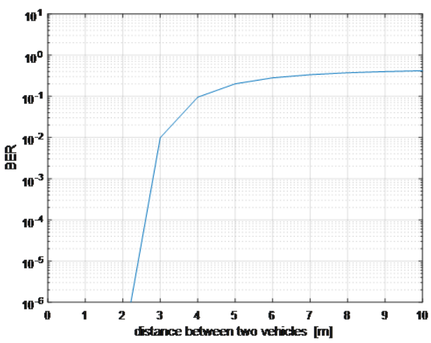

Figure 4. *The BER between two vehicle using OOK schemes*

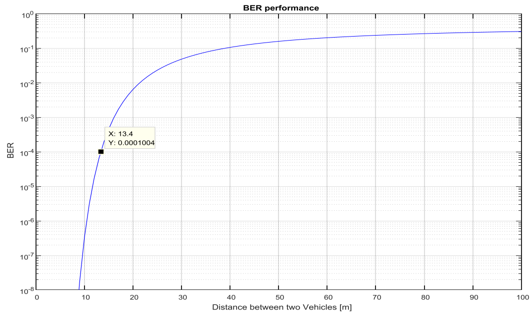

Figure 5. *The distance between two vehicles using 8-PPM scheme*

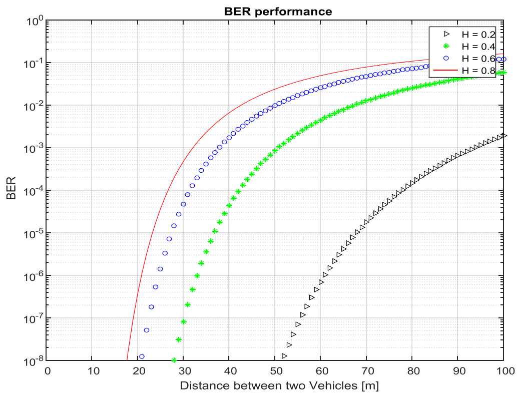

Figure 6. *The distance between two vehicles according to height of the head lamp*

Fig. 5 shows the communication distance between two vehicles has been increased when the proposed modulation scheme has been used in full simulation LOS and NLOS both the result come out with head of tail lamp of 0.2 m and BER $10e^{-4}$ is 13.4 m. In our proposed system the angles of radiation and acceptance has been modified to 75 ,60 respectively normal to x-axis, and The value of the Illumination factor Io=10, the system response has been improved as in the fig.6.

Fig. 6 shows that, two vehicles could communicate with high quality when the height of the headlamp is short, at BER of 10^{-4} which consider as the proposed value give high quality of communications, the distance between vehicles gave according to its head lamp's height. when the height is 0.2 m we can get communication signal up to 78m which is good but the position of lamp is not matching to the standard of vehicle's design and easy could affect interference and noise due it lower height, when the height of the headlamp increased the communication distance when reducing, as at 0.4m we get communication signal up to 42m, at lamp height of 0.6 cars can communicate with distance of 32m, and finally at standard position of headlamp, communication signal is available on 27m which is the best value we proposed.

Conclusion

In this paper led-based headlamps has been used for vehicle to vehicle communication for both LOS and NLOS under lambertian model. BER performance of a V2V VLC system using 8-pulse position modulation was simulated. the simulation assumed daytime model. Ambient noise is numerically analyzed. The simulation using Matlab software carried out result of the distance communication between two vehicle is 27 m at the height of LED-headlamp of 0.8m. which is consider best performance compare with the tradition modulation scheme.

References

[1] Mohammed Musa Mohammed Musa, H.Q., doi: , *A Novel Illumination Distribution Arrangement for Indoor VLC Using 17 Locations of Light Source*. Advances in Wireless Communications and Networks, 2018. **4**(2): p. 5-10.

[2] Wu, D., et al., *Short-range visible light ranging and detecting system using illumination light emitting diodes*. Vol. 10. 2016. 94 – 99.

[3] Farahneh, H., et al., *Performance analysis of adaptive OFDM modulation scheme in VLC vehicular communication network in realistic noise environment*. 2018. **2018**(1): p. 243.

[4] Grobe, L., et al., *High-speed visible light communication systems*. IEEE Communications Magazine, 2013. **51**(12): p. 60-66.

[5] Wang, C., et al., Cellular architecture and key technologies for 5G wireless communication networks. IEEE Communications Magazine, 2014. 52(2): p. 122-130.

[6] Ndjiongue, A.R. and H. Ferreira, *An Overview of Outdoor Visible Light Communications*. Vol. 29. 2018.

[7] *Global Status Report on Road Safety 2015*. , World Health Org., Geneva, Switzerland, , 2015.

[8] Karunatilaka, D., et al., *LED Based Indoor Visible Light Communications: State of the Art*. IEEE Communications Surveys & Tutorials, 2015. **17**(3): p. 1649-1678.

[9] Luo, P., et al., *Performance analysis of a car-to-car visible light communication system*. Applied Optics, 2015. **54**(7): p. 1696-1706.

[10] Armstrong, J., Y.A. Sekercioglu, and A. Neild, *Visible light positioning: a roadmap for international standardization*. IEEE Communications Magazine, 2013. **51**(12): p. 68-73.

[11] Hou, R., et al., *A Brief Survey of Optical Wireless Communication*. Vol. 163. 2015. 41-50.

[12] Komine, T. and M. Nakagawa, *Fundamental analysis for visible-light communication system using LED lights*. IEEE Transactions on Consumer Electronics, 2004. **50**(1): p. 100-107.

[13] Lausnay, S., et al., *Matlab based platform for the evaluation of modulation techniques used in VLC*. 2014. 57-61.

[14] Ghassemlooy, Z., et al., *BIT-ERROR-RATE PERFORMANCE OF A CAR-TO-CAR VLC SYSTEM USING 2×2 MIMO*. Vol. 11. 2015.

[15] Bekhrad, P., E. Leitgeb, and H. Ivanov. *Benefits of visible light communication in car-to-car communication*. in *SPIE Photonics Europe*. 2018. SPIE.

[16] Akanegawa, M., Y. Tanaka, and M. Nakagawa, *Basic study on traffic information system using LED traffic lights*. IEEE Transactions on Intelligent Transportation Systems, 2001. **2**(4): p. 197-203.

[17] Kimoto, R., et al. *Inverse pulse position modulation schemes for simultaneous visible light wireless information and power transfer*. in *2017 27th International Telecommunication Networks and Applications Conference (ITNAC)*. 2017.

[18] Elganimi, T., *Performance Comparison between OOK, PPM and PAM Modulation Schemes for Free Space Optical (FSO) Communication Systems: Analytical Study*. Vol. Vol.79. 2013. pp. 22-27.

[19] Yu, S., et al., *Smart automotive lighting for vehicle safety*. IEEE Communications Magazine, 2013. **51**(12): p. 50-59.

[20] Kim, Y.-h., W. Cahyadi, and Y.-H. Chung, *Experimental Demonstration of VLC-Based Vehicle-to-Vehicle Communications Under Fog Conditions*. Vol. 7. 2015. 1-1.

[21] Komine, T., et al., *Adaptive equalization system for visible light wireless communication utilizing multiple white LED lighting equipment*. IEEE Transactions on Wireless Communications, 2009. **8**(6): p. 2892-2900.

Citation: *Mohammed Musa, Hongbing Qiu.," Distance Estimation Using 8-PPM For V2V Visible Light Communication Using ",International Journal of Research Studies in Science, Engineering and Technology, vol. 5, no. 11, pp. 1-6, 2018.*