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ISSN (Online) 2394-2320

International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

Vol 5, Issue 2, February 2018

Light Fidelity (Li-Fi) Transceiver for Data Transmission Environment Based on MATLAB Simulation and System Design

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Abstract: **- Usage of light emitting diode (LED) is rapidly growing due to its reliability, low power consumption and high efficiency. Visible light communication (VLC) technique using white light emitting diode (LED) is a promising technology for next generation short range communication and high speed wireless data transmission. In this paper, indoor Light Fidelity (Li-Fi) Transceiver for Data Transmission is designed and System model considers the Position of light - emitting diodes (LEDs) as well as the detectors.The transceiver is able to transferData like "Character – Text Files – photo – audio" through modulated LED light beam using OOK modulation technique. This transceiver proposedplatform software that we developedto be able to upload the required data .abase 64 coding process is performed then the coded data is transmitted via LEDs. The coded data is received via photo transistor at receiver side and then decoded to be returned to its original form. A simulation program written in MATLAB is used also to plot the distributions of illuminance and the transmitted powers calculated mathematically according to data sheet of LED.**

Index Terms- **Visible Light Communication (VLC), light emitting diode (LED), transmitter (TX), receiver (RX).**

I. INTRODUCTION

The radio spectrum is highly congested and the demand for wireless data is making this much worse. Bandwidth required for the RF communications is rapidly getting exhausted. In current situation, more bandwidth is being found but it's clearly not enough, it is finite. More nodes are being added, cell splitting has been done for years but this is expensive. Also, two nodes do not have double the capacity of one as dueto interference issue, the law of diminishing returns is at play. Moreover, doubling the infrastructure will not double the revenue. Spectral efficiency also improved over the years, but recently the increase in wireless spectral efficiencies has slowed. Furthermore, research on hazards of RF have found that extreme RF radiation have adverse effect on environment [1], [2]. Visible light being a natural source of energy can be thought of has an alternative to the RF communication .LEDs can be switched off and switched on faster than we can perceive. This on-off motion can be used to represent 0's and 1's in other word, digital communication. A sequence of such variation can cause a flow of data. Visible communication is typically implemented using white LED light bulbs. These devices are normally used for illumination by applying a constant current through the LED. However, by fast and subtle variations of current, the optical output can be made to vary at extreme high speeds. Unseen by the human eye, this variation is used to carry high -speed data [2], [3].

II. VISIBLE LIGHT COMMUNICATION TECHNIQUE (VLC)

The Visible Light Communication (VLC) is a data communications variant which uses visible light between 400 and 800 THz (780–375 nm). VLC is a subset of optical wireless communications technologies[4].The high brightness LED's is the heart of this technology [5] .LEDs can be Switched on and off faster since operating speed of LED'S is less than 1μs, causing the light source to appear continuously which make a kind of data transmission using binary codes as switching "on "is a logical "1"and switching "off" is a logical "0", in other word, digital communication as shown in figure 1.The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbit/s, or LEDs for up to 500 Mbit/s. Low rate data transmissions at 1 and 2 kilo metres (0.6 and 1.2 mi) were

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International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)

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demonstrated. RONJA achieves full Ethernet speed (10 Mbit/s) over the same distance thanks to larger optics and more powerful LEDs[5], [6],this variation is used to carry high speed data. When signals reach the receiver through the indoor wireless channel, the photodiode will convert the optical signals to electrical ones and the original information will be recovered. VLC can be used as a communications medium for ubiquitous computing, because light-producing devices (such as indoor/outdoor lamps, TVs, traffic signs, commercial displays and car headlights/taillights) are used everywhere. Using visible light is also less dangerous for high-power applications because humans can perceive it and act to protect their eyes from damage [7].

Fig. 1 shows if the light is on then transmit a digital 1 .if it`s off transmit a 0 .The LEDs can be switched on and off very quickly which gives nice opportunities for transmitting data

VLC has a great a advantages like it causes no Interference with Radio Frequency (RF) devices , safety , band licensing-free so it is considered to be a safe alternative to radio frequencies and can be used in hospitals , Air ports and other electromagnetic interference sensible locations and provides cable free communication as shown in figure 2. [8], [9], [10]. We would like to construct a secured transceiver able to be used in the VLC environment.

Fig. 2 Visible Light Communication environment

III .MODELING OF OPTICAL CHANEL

We assume the following physical parameters for developing the simulation program: The distance between the first transceiver and the second transceiver is 1.5 m and the distance between the transmitter and the receiver in each transceiver is 30cm the designed model is shown in Figure 3. The other simulation parameters are listed in Table1.

Semi-angle at half power	70 [deg]
Center luminous intensity	0.73 [cd]
Number of LED each group	16(4x4)
Field of view	50 [deg]

Table 1. Simulation parameters.

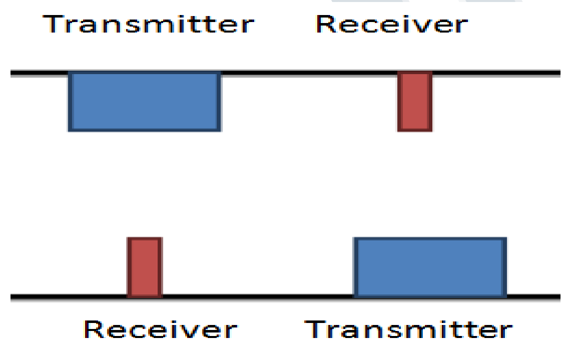

Fig. 3 the designed transceiver model

The distribution of illuminance at a working plane is discussed. It is assumed that the source of emission and the reflected points on wall have a Lambertian radiation pattern [11, 13, 14]. The lambertian emission means that the light intensity emitted from the source has a cosine dependence on the angle of emission with respect to the surface normal. Following the function for an optical link [11, 12-15], the luminous intensity in angle ϕ is given by:

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

Where I(0) is the center luminous intensity of the group LEDs, ϕ is the angle of irradiance, m is the order oflambertian emission and is given by the semi-angle at half illuminance of the LED $\phi_{1/2}$ as:

$$m = \frac{\ln 2}{\ln(\cos\phi_{1/2})} \quad (2)$$

A horizontal illuminance (E_{hor}) at a point (x,y,z) on the working plane is given by :

$$E_{hor.}(x,y,z) = \frac{I(0)\cos^m(\emptyset)}{D^2.\cos(\psi)} \quad (3)$$

Where D is the distance between transmitter and receiver, ψis the angle of incidence. To survey the illuminance distribution of LEDs system, the communication model for an individual LED is depicted in Fig.4, including a LED source, transmission channels and an optical receiver.

A.Transmitter

It is assumed that an LED has a lambertian radiant intensity [16][17],

$$Ro(\emptyset) = \left[\frac{m+1}{2\pi}\right]\cos^m(\phi) \quad (4)$$

Where m is the order of lambertian emission, and is related to $\phi_{1/2}$, the transmitter semi-angle (at half power) as m =−ln2/ ln (cos $\phi_{1/2}$). The power emitted by the LED is PLED, and ϕ ,ψ are the irradiance and incidence angles. The transmitted power is Ptx= PLED x Ro (ϕ).

B. Channel

Light beams propagate from the LED to the receiver via two main channels: light of sight (LOS) and diffuse channels. In this section, light of sight channel model will be discussed .The DC gain can be estimated accurately by considering only the LOS propagation path [18]. Equ.5 expresses the channel transfer function:

$$H(0)_{los} = \{\frac{A_{rx}}{d^2} R_o\left(\phi\right)\cos(\psi) \qquad 0 \le \psi<\psi c \quad (5)$$

Where Arx is the detector area, d is the distance between the transmitter and the receiver, $R_o\left(\phi\right)$ is the transmitter radiant intensity and given by Equ.1, ψ is the angle of incidence; ψcis the field of view (FOV) of the photodiode. The total power of i LEDs in the directed path, see Figure 5is calculated in Equation.6:

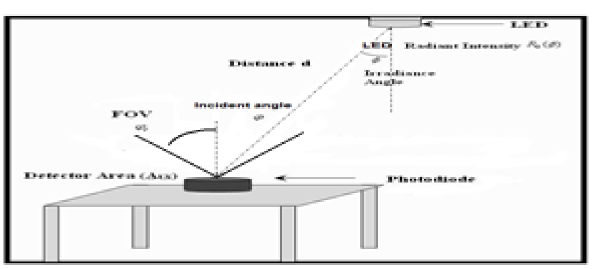

Fig. 4 System model with one LED

$$P_{rx,LOS}= \sum_{i=1}^{LEDS} P_{tx} H^i_{LOS}(0) \quad (6)$$

Where H iLOS (0) is the number of LED channel DC gain.

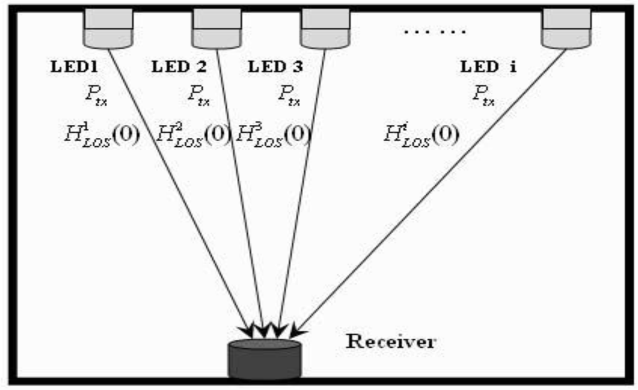

Fig. 5 System model with LED arrays

We assume the configuration for LED position In case of the first transceiver, is in the left of the ceiling, and for the second transceiver will be located at the right position like Figure 6.

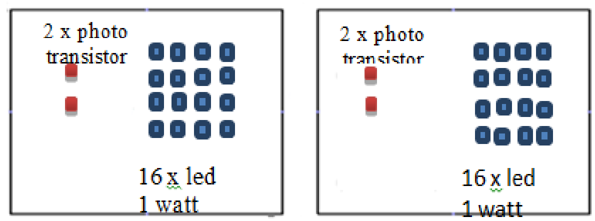

Fig. 6 the position of LEDs and photo transistors on both transceivers

We used MATLAB2007R program to develop the simulation program. First, the program calculates the direct illumination, for one or plural transmitters with lambertian radiation pattern (the results are given by many previous researches [13, 14] in case on using one transmitter. we have created a program that used to simulate a radiation pattern in case of using transceiver which will be showed in the next section.

IV. ILLUMINANCE PERFORMANCE

The distribution of illuminance of our system is shown in figure below: Figure 7 shows the illuminance with 1 transmitter, the sem iangle at half power is 70 degree. The maximum value of luminous flux in the center is 250.10 lx. Figure 8 below shows the distribution for two transmitters with the semi angle of 70 degree. The performance of LEDs with narrow field of view is shown in here. It opens a chance for improvement LEDs with the wide field for illuminance on case of using the transceiver in the VLC environment. The value is in the range from 24 to250 lx. Figure 9, Fig .10shows the 3D simulated curve obtained using Equ.4 that indicates the channel transfer function of i LEDs in the directed path and the 2D curve of the channel transfer function respectively. The 3D curve of the total power of i

ISSN (Online) 2394-2320

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LEDs in the directed path and the 2D curve is shown in Figure 11, Fig.12 respectively as well.

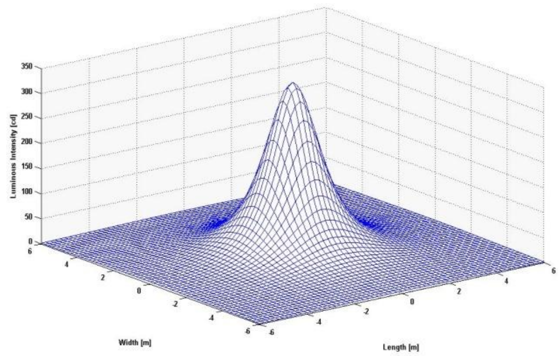

Fig. 7 the distribution of illuminance in case of one transceiver Max value 250.10 lx

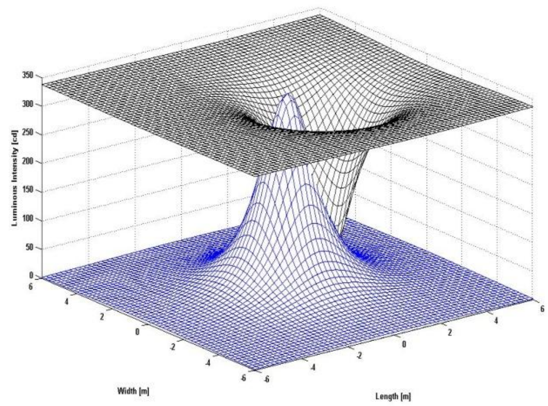

Fig. 8 the distribution of illuminance in case of two transceivers one with blue colour and the other with the black distribution Max value of both 250.10 lx

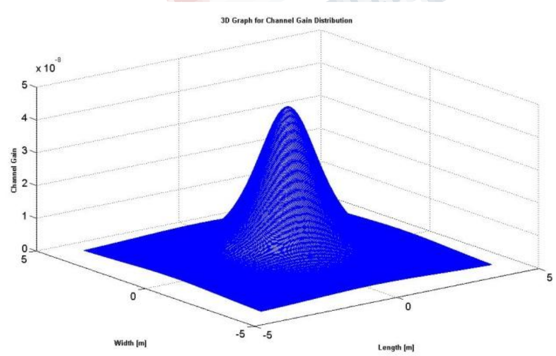

Fig. 9 the distribution of the channel transfer function of i LEDs

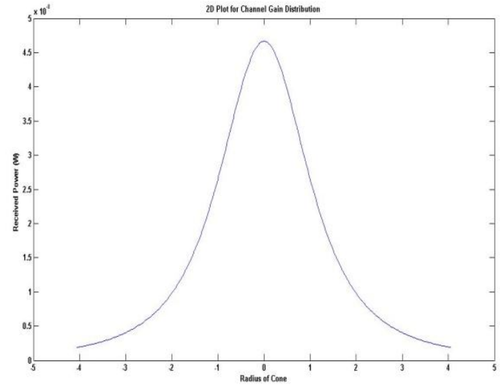

Fig. 10 2D plot of the channel transfer function of i LEDs

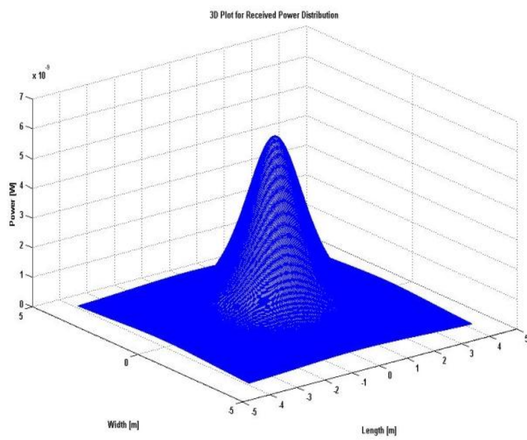

Fig. 11 the distribution of the total power of i LEDs

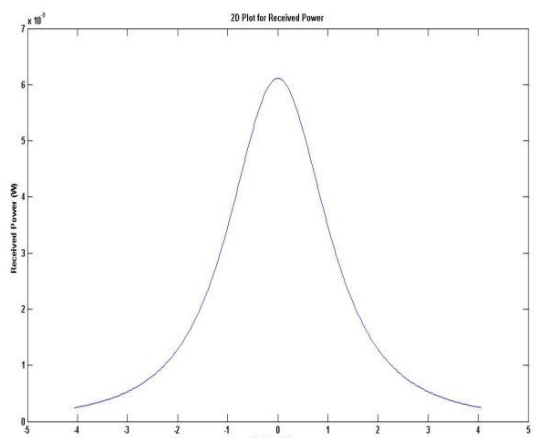

Fig. 12 2D plot of the total power of i LEDs

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ISSN (Online) 2394-2320
International Journal of Engineering Research in Computer Science and Engineering (IJERCSE)
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V. DESIGN AND IMPLEMENTATION

A. The VLC Block Diagram:

The design of VLC system is made to achieve the concept of transceiver between the two devices. The data will be uploaded via C# application on one of the devices then the C# application source coding process is performed after that the data is encrypted via base 64 technique then sent to the arduino attached to the device to be transmitted through White LEDs connected to the TX pin of the arduino. On the other hand the data is received via Phototransistor to be sent to the arduino pin RX which passes data to the computer to be decoded and reconstructed again to the original format via C# application. Figure 13 illustrates the block diagram of the VLCData transceiver system. Figure 14 (A)shows the flow chart of the C# application that we developed to be able to work as an interface between laptop (PC1) and the arduino using visual studio software and c sharp as a programming language. Figure14 (B) shows the flow chart that we developed to be able to work as an interface between the arduino and laptop (PC2).

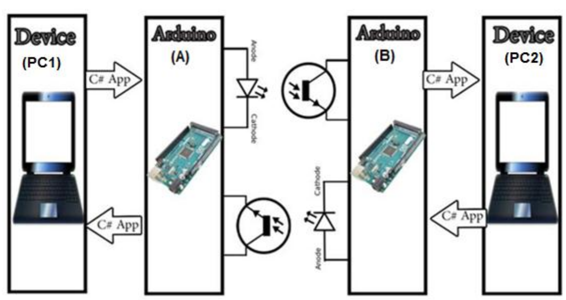

Fig 13 Block diagram of transceiver VLC system

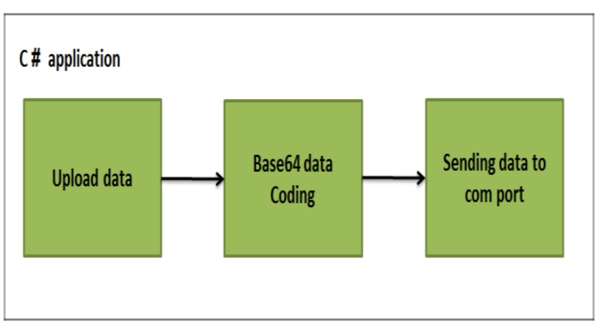

Fig 14 (A) C# application in TX direction.

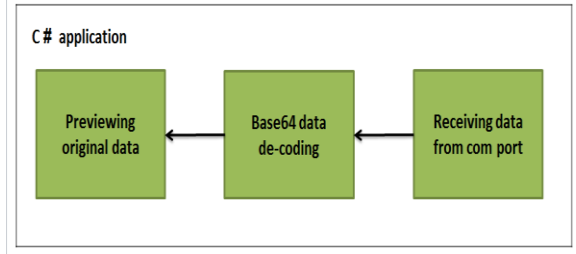

Fig 15 (B)C # application in RX direction.

A. Schematic Design:

The following figure represents the circuit diagram of our transceiver circuit as shown in figure 15 and followed with the explanation of circuit operation for transmitter and receiver separately:

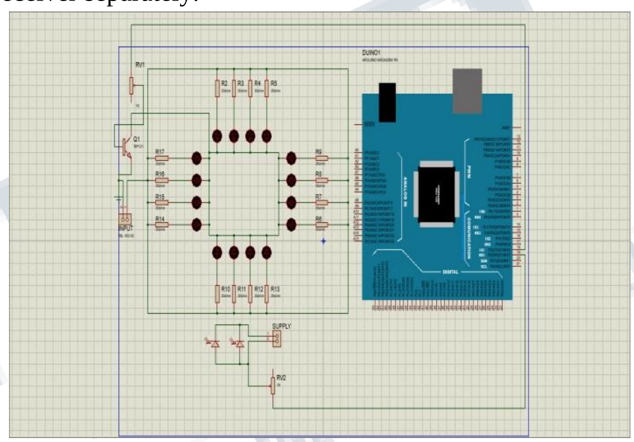

Fig. 15 Schematic Design of the transceiver VLC system

Circuit operation:

Transmitter side:

Transmitter Circuit Consists ofC#application, arduino, LEDs, Transistor (Tip 121), and variable Resistance. Transistor Used As a switch, LEDs to send the processed data obtained from C# application. The processed data is sent to Arduino (TX0 pin) that connected to the PC to be sent viaLEDs using OOK modulation.

Receiver side:

Receiver Circuit Consists of Phototransistor (PT204-6C), variable Resistance, arduino, C#application. The data sent from transmitter via LEDs is received by Phototransistor (PT204-6C), which is connected to variable Resistance to adjust the sensitivity of the phototransistor. The received data sent toarduino (RX0 pin) then to PC. Using C# Application on this PC to decompress andrestore the data in its primary form (photo, text, sound..., etc) .

ISSN (Online) 2394-2320

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VI. EXPERIMENTAL RESULTS

SENDING AND RECEIVING DATA USING C # APPLICATION:

- C # application is a communication and terminal emulation program that can be setup and work with the Windows Operating System, beginning with Windows 98.
- C # application has the main window as shown in figure 16 which include option to upload the required data as well as choosing the transceiver to work as a transmitter or receiver
- The transmit window of the application is shown on figure 17 as we have to load the required data from load tab for example we will take a photo to be send and click on send data to be forwarded to TX of arduion pin.
- The received window is shown on figure 18. we have to check start receive photo to begin receive the coded data to be reconstructed to original data then click on view photo to review it to original data Figure 19 (a) , (b) shows the coded data in the transmitter side and the decoded data in the receiver side as well as previewing the original data without encryption process . We have taken JPG picture to be sent from transmitter to receiver side as an example.

Fig. 16 Main window of C #application

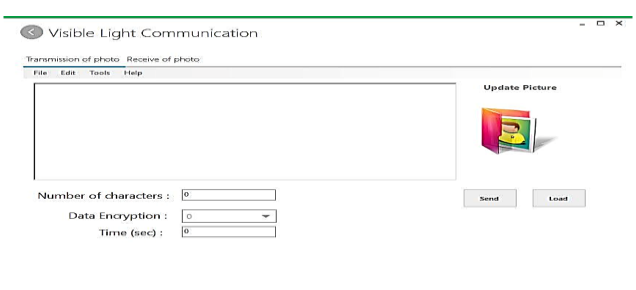

Fig. 17 transmitter window of C #application at transmitter side

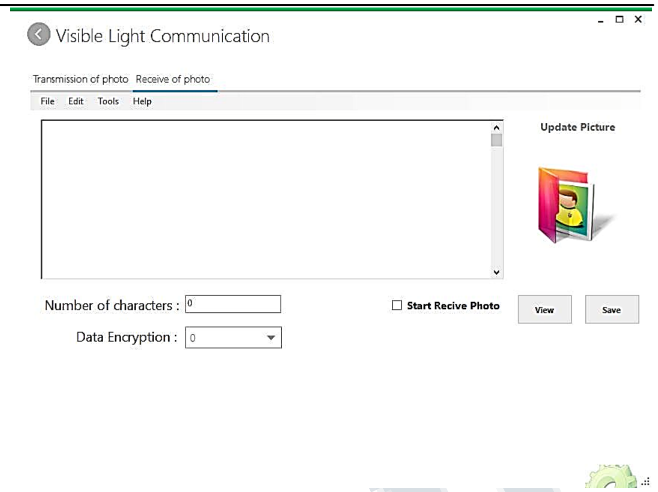

Fig. 18 the receiver window of C #application at receiver side

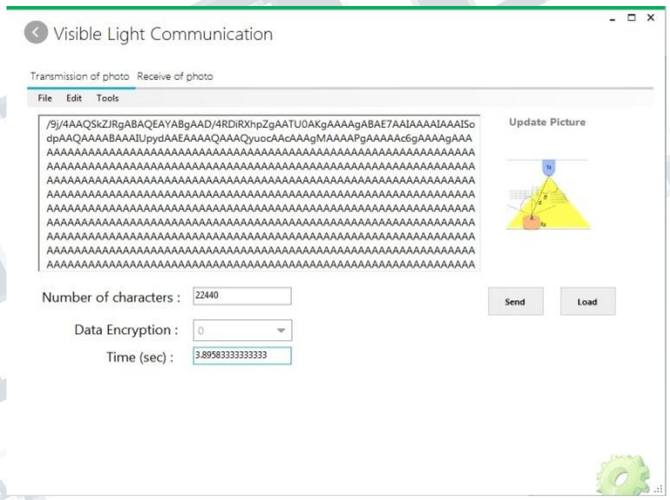

Fig. 19 (a) coded data in the transmitter side.

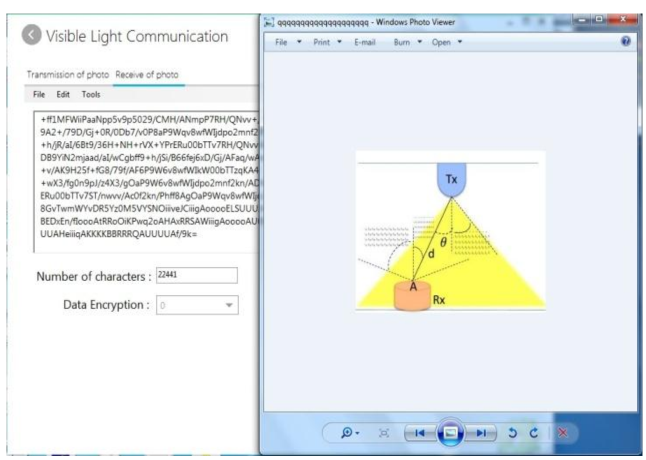

Fig. 19 (b) decoded data in the receiver side.

VII. CONCLUSION

In this paper, we have reported the simulation program for indoor visible light communication environment based on MATLAB. Using the simulation program, the distribution of illuminance analyzed at bottom surface and top surface as well as the power of the transmitted led and LOS channel is considered. An indoor Light Fidelity (Li-Fi) Transceiver for Data Transmission is designed by using software that we have developed to be able to upload the required data to be processed and sent from transmitter to receiver and vice versa depending on half duplex techniques. It is expected to be upgraded with more realistic encryption and decryption techniques as well as advanced modulation formats.

VIII. FUTURE WORK

In future, we are going to enhance the Optical Transceiver for Data Transmission via Visible Light Communication (VLC) Technique with C# application able to encrypt and decrypt the data to be more secured as well as trying to increase the bit rate of the transmitted data.

REFERRENCES

[1] ShaistaTarannum, " Data Transmission Through Smart Illumination via " Visible Light Communication Technology " ", International Journalof Technical Research and Applications, Volume 4, Issue No. 2 , PP. 136-141, (March-April, 2016).

[2] Stanislav ZVANOVEC, Petr CHVOJKA, Paul Anthony HAIGH, ZabihGHASSEMLOOY, "Visible Light Communications towards 5G",RADIOENGINEERING, VOL. 24, NO. 1, APRIL 2015.

[3] DobroslavTsonev, Stefan Videv and Harald Haas, "Towards a 100 Gb/s visible light wireless access network", Optical Society of AmericaVol. 23, No. 2, 26 Jan 2015.

[4] U.SUGANYA1, C.SUBHALAKSHMIPRIYA, "Li – FI (Light Fidelity) Technology ", INTERNATIONAL JOURNAL OF RESEARCH INCOMPUTER APPLICATIONS AND ROBOTICS " , Vol.3 Issue No.1, PP. 26-32, January 2015.

[5] K. Sindhubala and B. Vijayalakshmi, "Design and Implementation of Visible Light Communication System In Indoor Environment", ARPNJournal of Engineering and Applied Sciences " , VOL. 10, NO. 7, APRIL 2015.

[6] PokpoomChanthosot ,VittayaTipsuwanporn , ViriyaKrongratana and ThanapornLilawatthananun, "The Indoor Use Development forVisible Light Communication", Proceedings of the World Congress on Engineering and Computer Science 2015 Vol I WCECS 2015,October 21-23, 2015, San Francisco, USA

[7] Sathiya.T ,Prof.E.Divya , Prof.S.Raja, "Visible Light Communication for Wireless Data Transmission", International Journal of InnovativeResearch In Electrical, Electronics, Instrumentation and Control Engineering " ,Vol. 2, Issue No. 2, February 2014.

[8] Rahul R. Sharma, AkshaySanganal, SandhyaPati, "Implementation of A Simple Li-Fi Based System", International Journal of Computingand Technology, Volume 1, Issue No. 9, October 2014.

[9] AbhishekKurup, VipinTiwari, Selvanathiya, "Implementation and Demonstration of LI-FI Technology", International Journal of Research inEngineering and Technology, Volume: 03, Issue No. 03 , Mar-2014.

[10] MeghaGoyal, Dimple Saproo, AshaBhagashra, "New Epoch of Wireless Communication: Light Fidelity", International Journal ofInnovative Research in Computer and Communication Engineering, Vol. 1, Issue No. 2, April 2013.

[11] A. Sivabalan and J. John, "Improved power distribution in diffuse Indoor Optical Wireless systems employing multiple transmitterconfigurations," Opt. Quantum Electron.38, 711-725 (2006).

[12] T. Komine, M. Nakagawa "Fundamental Analysis for Visible Light communication system using LED light," IEEE Trans.Consum. Electron.50, 100-107 (2004).

[13] T. Komine and M. Nakagawa, "Performance evaluation of Visible- Light Wireless Communication System using White LED Lighting," in Proceedings of the Ninth IEEE Symposium on Computers and Communications, pp.258-263 (2004).

[14] T. Komine, S. Haruyama and M. Nakagawa, "A Study of Shadowing on Indoor Visible-Light Wireless CommunicationUtilizing Plural White LED Lightings," Wireless Pers. Commun. 34, 211-225 (2005).

[15] K. Fan, T. Komine, Y. Tanaka, M. Nakagawa, "The Effect of Reflection on Indoor Visible-Light

Communication System utilizing White LEDs," in Proceedings of the 5th Int. Symposiumon Wireless Personal Multimedia Communications (WPMC2002), pp. 611-615 (2002).

[16] Joseph M.Kahn and John R.Barry, "Wireless Infrared Communications", Proc.IEEE, Vol. 85, No. 2, PP. 265-298, 1997.

[17] F.R.Gfeller and U.Bapst, "Wireless in-house data communication via diffuse infrared radiation," Proc.IEEE, Vol. 67, No 10, PP. 1474 1486, 1979.

[18] Joseph M.Kahn and John R.Barry, "Wireless Infrared Communications", Proc.IEEE, Vol. 85, No. 2, PP. 265-298, 1997.