Secure of Transmission Systems in the Visible Range of Light with the Power Line Communication Interface

Haider Al-Janabi
Department of Communications Engineering Techniques Imam Ja'afar Al-Sadiq University, Iraq
dr.haider.dhiaa@sadiq.edu.iq

Hussam Al-Janabi
Department of Computer Engineering Techniques, Al-Mustafa University College, Iraq
hussam.cet@almustafauniversity.edu.iq

Bashar Qas Elias
Department of Communications Engineering Techniques, Imam Ja'afar Al-Sadiq University, Iraq
bashar.bahaa@sadiq.edu.iq

Abstract: *The paper discusses the issue of creating a secure environment for information transmission in an association dependent on Noticeable Light Correspondence (VLC) innovation utilizing a Power Line Correspondence (PLC) modem. Throughout the examination, an investigation of homegrown and unfamiliar writing and patent documentation was done, which affirmed the significance of this point and the need to improve and adjust the innovation for homegrown associations, the conceivably better security of the framework from unapproved admittance to information was validated in correlation with wired and Wi-Fi organizations., which executes information transmission dependent on VLC innovation, utilizing Light-Emitting Diode (LED). Lighting sources as transmitters of the correspondence framework, with the coordination of the PLC interface. The utilization of the PLC interface makes it conceivable to improve on the establishment and execution of the VLC communicating modules since the data signal is provided to the last through the electrical cables that give capacity to the lighting installations. An evaluation of the working states of an information transmission framework dependent on VLC innovation with a PLC interface was completed, which uncovered that with the base admissible sign to-clamor proportion equivalent to 6 dB, the channel data transfer capacity is 8 Mbps, and the bit mistake rate will in general zero. The examination results can be utilized to assemble a corporate organization utilizing VLC innovation with a PLC interface, and discover their application for additional investigation of this innovation.*

Keywords: *VLC, Li-Fi, PLC, FSO, data visible light, passing module, optical signal telecommunication system.*

Received June 11, 2021; accepted August 15, 2021
https://doi.org/10.34028/iajit/19/5/7

1. Introduction

The use of wireless Wi-Fi networks in organizations is one of the vulnerabilities to interception by hackers. So, many enterprises have Wi-Fi enabled for transmission of data in selected segments of the corporate network, even though it potentially poses a threat to the security of your data. Al-janabi *et al*. [1] and Ning *et al*. [13] It is evident that with the increase in traffic over wireless and, therefore, accessible for analysis and interception of communication channels are becoming sharper questions related to protection from unauthorized access in the corporate world.

The standard means protecting information as provided for the specifications of the Wi-Fi-WPA and WPA2 and using the authentication and data encryption for all subscribers, with the development of computer technology is losing its effectiveness as in Dheepan *et al*. [7].

As with any other radio communication systems in networks of Wi-Fi equipment, electromagnetic compatibility issues, congestion frequency ranges. Virtually any Wi-Fi router, used in corporate networks, is clocked at 2.4 or 5 GHz, in the same range working microwaves, various industrial equipment, as well as related Wi-Fi network, and the result of interference from deterioration and even loss of signal, a significant speed reduction, and hardware failures, Goswami and Shukla [8].

Different various assessment yields on Optical distant correspondence development have been given either for compromise with existing advances or for operating wholly on Optical remote correspondence mechanical expertise. Chowdhury *et al*. [6] presented the progression of light-reliability (Li-Fi) structures to be solid in cell networks mistreatment balanced repeat Orthogonal Frequency-Division Multiplexing (OFDM). Potential transmission plots that might be utilized for these structures were furthermore inspected. The principal elements of Noticeable Light Correspondence (VLC) and Power Line Correspondence (PLC) systems were investigated by Arfaoui *et al*. [4]. The central objective was to seek out the shot at coming up with PLC and VLC for indoor correspondence. PLC is AN advancement that clears method for this power connects to be utilized for

causing data. Multiple-Input and Multiple-Output (MIMO) techniques for the planned structure were equally discussed. It's accomplishable to management the LEDs using the info that is being sent by the electrical link Arfaoui *et al*. [3], and this makes the VLC slot in all right with PLC. As indicated by the frameworks organization perspective, gave a paper, which was focused on Free-Space Optical (FSO). Their work realized habits by which execution of FSO in cell associations will be dead to lift the constraint of the association.

The remaining of this paper is organized as follows: Literature review of previous studies, the Development of transferring and the reception parts of the system, the Necessary Calculations When Implementing Systems Based on Technology VLC, and Conclusion of our study like the study presented in Alresheedi *et al*. [2].

2. Literature Review

In Alresheedi *et al*. [2] was present the numerous problems that exist in distant RF making progressions were explored. Studies were finished a perspective on however these issues could also be modified mistreatment VLC structures. Besides, a discussion on applications, answers for this VLC troubles, and future upgrades was given. Heterogeneous systems, using each VLC and much off RF. one among the promising techniques to deal with the fundamental challenges in 5G remote associations, called optical ulceration (O-NOMA), was presented by Căilean and Dimian [5] and Wang *et al*. [16]. A state of the art mixture of O-NOMA into VLC networks was ordered out and analyzed thoroughly. Current troubles and anticipated that freedoms ought to enable the plans and connexion of O-NOMA into VLC structures were additionally given.

A show of an imaging MIMO VLC system was given by Wang *et al*. [15]. The manufacturers widened the information measure of the light-emitting diode transmitter mistreatment the preequalization system. With this method, the ability of fragments of high repeat, for instance, LEDs will be through and thru improved whereas draining the low repeat was given by Ning *et al*. [11]. The manufacturers used the OFDM and bit-stacking computation for his or her modification plot. mistreatment the planned structure, it had been displayed that the one exchange speed of the phosphor-shrouded light-emitting diode is ready for achieving an information speed of one Gbps over a transmission distance of 1 in free-space was given by Al-janabi *et al*. [1].

In VLC structures, there's no essential for refined radio wires to send data from the sunshine supply through air. An additional issue that creates VLC structures appealing over RF systems is that they need trademark security. The management of sent data within the real layer is direct as correspondence is unremarkably in the Line of Side (LoS). This dodges assault of the correspondence system by offish gossips. What' more, rather than RF, recognizable light isn't prepared for coming into solid surfaces like dividers. The backwardness of divider entrance allows the creation of very little cells to send while not ohmic resistance between cell regions and in Figure (1) shown the Visible Light Communication System, as in Ning *et al*. [12].

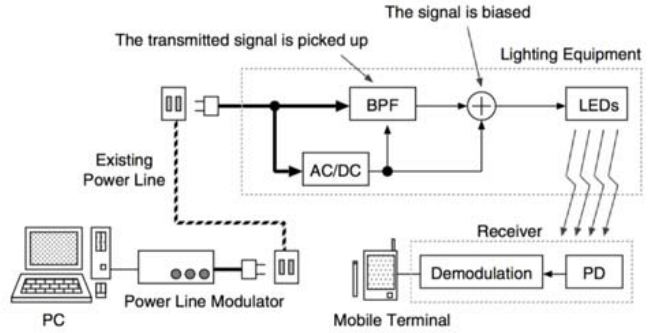

Figure 1. Visible light communication system.

There is one way to improve the security of transmitted data in enterprise networks and solutions to the problems of electromagnetic compatibility of radio facilities with high-speed data transfer requirements and mobility subscriber devices is using the technology of VLC (visible light communication-"transmission of visible light"). This technology applies to wireless and uses optical radiation in the visible range of the spectrum (wavelength from 380 nm to 780 nm) as a carrier of data, was presented in Căilean and Dimian [5] and Chowdhury *et al.* [6]. In other words, the basis of VLC is available technology optical communication system, in which the transmitter module supports led/led lighting system selected premises.

In the present time, advances in led production allowed to significantly increase their energy efficiency and performance, opening up prospects for the use of communications systems with visible light for use in corporate networks data, was presented in Arfaoui *et al*. [3].

Analysis of the literature indicates the relevant topic and the highest interest of the scientific community to the problems of realization of VLC. So, Alresheedi *et al*. [2] analyzed the features of VLS technology applications in places where it is forbidden to use radio equipment (resuscitation of the Chamber of medical institutions, aircraft, etc.).

The proposed scheme of data transmission system based on the technology of VLC implements the manipulation of intensity-for transferring logical unit on a photodetector per unit time must do the optical signal for transmission of logical zero per unit of time the signal is absent was presented in Al-janabi *et al*. [1] and Wang *et al.* [15].

Optical signal modulation techniques are analyzed for use in VLC systems. Methods for OFDM (Orthogonal frequency-division multiplexing) and CSK (Code Shift Keying) are identified as the most difficult to implement while obtaining the maximum data transmission speed in the 100 Gbit/s was presented by Vappangi and Vakamulla [14].

Based on the literature and patent review classification approaches and technologies of data transmission systems based on VLC. By the number of emitting LEDs on the transmitter side, you can select the system was presented by Ning *et al*. [11]:

By the number of emitting LEDs on the transmitter side, you can select the system using:

- One information of the LED array composed of non-information.
- An array of information LEDs.
- Block of LEDs of different colors.

According to the method of optical radiation modulation of LEDs, the following approaches build VLC systems, was presented by Zhou *et al*. [17] and Ning *et al*. [12]:

- OOK (On-Off Keying, the simplest form of manipulation by intensity).
- PPM (phase-pulse modulation).
- VPPM (Variable Pulse Width Modulation)
- OFDM (Orthogonally Frequency Division Modulation channels).
- CSK (Code Shift Keying).

Analysis of patent documentation and literature allowed the synthesis of the generalized structured scheme so you can implement any of the designated modulation techniques within VLC using interface technology PLC.

The technology of PLC data transmission over power lines") is a telecommunications technology based on electric systems for high-speed information exchange. The possibility of using PLC technology will simplify the installation and installation of the VLC system and increase reliability in terms of information security was presented by Khan *et al*. [9] and Lemeshko *et al*. [10]. Figure 2 shows a diagram illustrating the operation principle of VLC technology with a PLC interface.

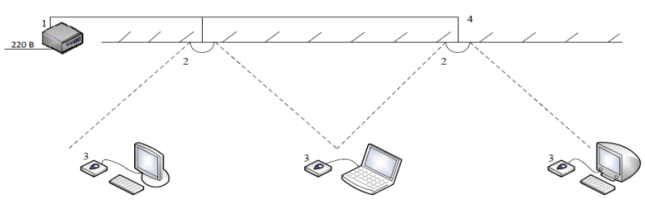

Figure 2. The principle of operation of VLC technology with a PLC interface (1-PLC adapter, 2-VLC transmitter module, 3-VLC receiver module, 4-power line).

3. Development of Transferring Part of the System

The voltage signal information is highlighted in passing the VLC module information signal on power lines through the PLC modem. The transmitting module includes a matching device, a modulator; an LED control device, and an LED lighting source (Figure 3).

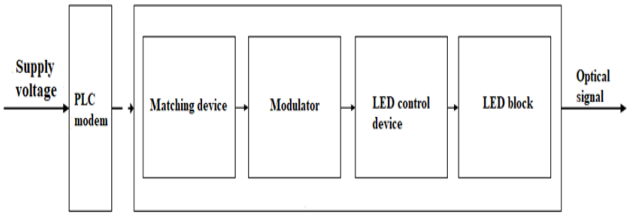

Figure 3. Block diagram of a transmitting module of VLC technology with a PLC interface.

Linkage causes the output signal settings required to control modulator LEDs (matching the input parameters with the device-led control parameters). The modulated signal is sent to the control unit LEDs constituting a charge containing a microcontroller, the brightness control, frequency of flicker and choice necessary LEDs from the block.

4. Development of the Reception Part of the System

VLC module technologies is a small unit, which is based on the photodetector (Figure 4).

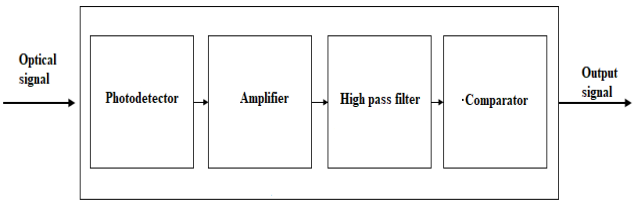

Figure 4. Block diagram of the receiving module of VLC technology with PLC interface.

From the yield of the photodetector, the recognized sign falls on a low-commotion enhancer and channel to limit clamor. Normally, the commotion in the VLC beneficiary is like that of a regular optical connection recipient. This can be warm commotion from the heap resistor and photodiode, inordinate clamor from the intensifier, shot clamor, and some other light sources in the room.

The prepared sign to the contribution of the comparator, which changes over a simple sign into a computerized embraced arrangement, is fostered the construction carries out the simplex mode. To execute a duplex plan is supplemented by an uneven channel.

5. The Necessary Calculations when Implementing Systems Based on Technology VLC

To analyze the characteristics of the implementation of the system of VLC in a particular room selected rectangular room with a length of 17 meters, a width of 11 meters, and height of 3.5 meters. The main parameters of the optical transmitter and receiver are displayed in Table 1.

Table 1. Optical transmitter and receiver parameters.

Parameter	Value
Optical transmitter power	0.18 mw
(LED)	
Bandwidth	2 MHz
Operating wavelength	870 nm
Current sensitivity of photodiode	0.62 A / W
Noise current of photodetector	1.25 Pa / Hz

Given the effects of scattering and absorption of visible light in the atmosphere and the characteristics of the equipment used, you can calculate the maximum distance at which will transfer data will be made with an acceptable coefficient of errors. This requires that the signal/noise ratio, which represents the effective voltage signal to the effective voltage noise receiver for digital systems, was higher than 6 db.

By substituting the sensitivity values of the photodetector and the noise current, it is possible to calculate the receiver's internal noise.

$$P_{noise} = \frac{1.25*10^9 \frac{A}{GH}*2GH}{0.62\frac{A}{W}} = 0.004\ mw \quad (1)$$

Then, for the signal power required at the input of the receiver module to provide the desired signal/noise ratio, we can write:

$$Psignal = (10SNR/10) \cdot Pnoise \quad (2)$$

$$P_{signal}=(10^{6db/10})\cdot 0{,}004\ мw=0{,}016\ мw \quad (3)$$

VLC transmitter emits a signal power of 0.18 MW, and the minimum value on the receiver's input should be 0.016 MW. Referring to the law of Lambert-Beer-Beer, you can calculate the distance limit (D) to ensure acceptable attenuation.

The attenuation coefficient according to the Bouguer-Lambert-Beer law has the following form:

$$K=e^{-(Katm\cdot D)} \quad (4)$$

Where K is the attenuation coefficient, D is the distance, K_{atm} is the exponent absorption.

In this case, the absorption index is associated with a wavelength of 780 nm and a dimensionless absorption coefficient in the atmosphere of 75 dB.

$$K_{atm} = \frac{4\pi k}{\lambda} = \frac{4\pi.75db}{780nm} = 0.56\% \quad (5)$$

Expressing L and substituting the values, we find the distance at which the signal decays.

$$D = -\frac{\ln K}{K_{atm}} = -\frac{(ln0.09)}{0.56} \quad (6)$$

Assuming that all VLC receivers are located on the office table (the height of the table is taken equal to 1 m), and the maximum distance D=4, 3 m, you can find what area covers one transmitter mounted in the ceiling lighting system.

Coverage area from a transmitter shall be calculated by the formula:

$$S = \pi \cdot R = \pi(D^2 - L^2) \quad (7)$$

Where D is the distance from the transmitter to the receiver; L is the length of the transmitter normal to the receiver; R is the radius of the desired coverage zone.

Substituting all the values into formula (4), we get:

$$S=\pi \cdot (4.3^2 - 2.5^2) \approx 36m^2 \quad (8)$$

Since the area of the room under investigation is 187 m^2 and one transmitter is capable of covering an area of 36 m^2, six VLC transmitters mounted in the ceiling will be required for this dedicated room.

The optimal arrangement of the VLC LEDs of the transmitter in an office space of specified sizes is shown in Figure 5.

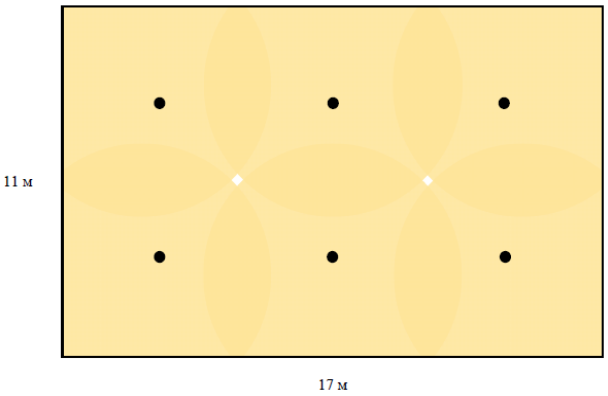

Figure 5. Premises coverage information component of optical radiation.

After analyzing the results acquired from utilizing the PLC interface makes it conceivable to work on the establishment and execution of the VLC communicating modules, since the data signal is provided to the last through the electrical cables that give capacity to the lighting apparatuses. An evaluation of the working states of an information transmission framework dependent on VLC innovation with a PLC interface was completed, which uncovered that with the base admissible sign to-clamor proportion equivalent to 6 dB, the channel transfer speed is 8 Mbps, and the bit blunder rate will in general zero.

6. Conclusions

A wireless system for transmitting data over an open channel based on VLC technology with a PLC interface is proposed. The use of this system in the implementation of the corporate network allows

achieving a high level of information security at the physical level, reducing the cost of data protection to a minimum. An analysis of literature and patent documentation was made, which confirmed the relevance of this subject and made it possible to classify all available solutions. A block diagram is proposed that implements data transfer based on VLC technology with a PLC interface consisting of two modules. The purpose of each of the nodes is described in this paper. The calculations show the process of implementing this system the results acquired from utilizing the PLC interface makes it conceivable to work on the establishment and execution of the VLC communicating modules since the data signal is provided to the last through the electrical cables that give capacity to the lighting apparatuses. An evaluation of the working states of an information transmission framework dependent on VLC innovation with a PLC interface was completed, which uncovered that with the base admissible sign to-clamor proportion equivalent to 6 dB, the channel transfer speed is 8 Mbps, and the bit blunder rate will in general zero.

The use of VLC technology with the PLC interface will reduce the chance of unauthorized access to the transmitted data. Since access to the necessary information requires an attacker to enter the premises directly, this greatly complicates the interception of data from the outside.

References

[1] Al-janabi H., Al-janabi H., and Al-Bukamrh R., "Impact of Light Pulses Generator in Communication System Application by Utilizing Gaussian Optical Pulse," *in Proceedings of the 22nd International Conference on Control Systems and Computer Science*, Bucharest, pp. 459-464, 2019.

[2] Alresheedi M., Hussein A., Elmirghani J., and Hussein A., "Uplink Design in VLC Systems with IR Sources and Beamsteering," *IET Communications*, vol. 11, no. 3, pp. 311-317, 2017.

[3] Arfaoui M., Ghrayeb A., and Assi C., "Secrecy Performance of the MIMO VLC Wiretap Channel with Randomly Located Eavesdropper," *IEEE Transactions on Wireless Communications*, vol. 19, no. 1, pp. 265-278, 2020.

[4] Arfaoui M., Soltani M., Tavakkolnia I., Ghrayeb A., Safari M., Assiet C., and Haas H., "Physical Layer Security for Visible Light Communication Systems: A Survey," *IEEE Communications Surveys and Tutorials*, vol. 22, no. 3, pp. 1887-1908, 2020.

[5] Căilean A. and Dimian M., "Current Challenges for Visible Light Communications Usage in Vehicle Applications: A Survey," *IEEE Communications Surveys and Tutorials*, vol. 19, no. 4, pp. 2681-2703, 2017.

[6] Chowdhury M., Hossan T., Islam A., and Jang Y., "A Comparative Survey of Optical Wireless Technologies: Architectures and Applications," *IEEE Access*, vol. 6, pp. 9819-9840, 2018.

[7] Dheepan K., "Security Enhancement and Certificate Revocation in MANET using Position and Energy based Monitoring," *The International Arab Journal of Information Technology*, vol. 16, no. 1, pp. 88-97, 2019.

[8] Goswami P. and Shukla M., "Design of a Li-Fi Transceiver," *Wireless Engineering and Technology*, vol. 8, no. 04, pp. 71, 2017.

[9] Khan M., Cherif W., Filali F., and Hamila R., "Wi-Fi Direct Research Current Status and Future Perspectives," *Journal of Network and Computer Applications*, vol. 93, pp. 245-258, 2017.

[10] Lemeshko A., Al-Janabi H., and Al-Dulaimi A., "Model Progress of Subchannel Distribution in WiMAX Antenna System," *in Proceedings of the International Conference on Antenna Theory and Techniques*, Kharkiv, pp. 1-3, 2015.

[11] Ning Z., Dong P., Wang X., Hu X., Guo L., Hu B., Guo Y., Qiu T., and Kwok R., "Mobile Edge Computing Enabled 5G Health Monitoring for Internet of Medical Things: A Decentralized Game Theoretic Approach," *IEEE Journal on Selected Areas in Communications*, vol. 39, no. 2, pp. 463-478, 2021.

[12] Ning Z., Sun S., Wang X., Guo L., Guo S., Hu X., Hu b., and Kwok R., "Blockchain-Enabled Intelligent Transportation Systems: A Distributed Crowdsensing Framework," *IEEE Transactions on Mobile Computing*, pp. 1-1, 2021.

[13] Ning N., Sun S., Wang X., Guo L., Wang G., Gao X., and Kwok R., "Intelligent Resource Allocation in Mobile Block Chain for Privacy and Security Transactions: A Deep Reinforcement Learning Based Approach," *Science China Information Sciences*, vol. 64, no. 6, pp. 1-16, 2021.

[14] Vappangi S. and Vakamulla V., "Synchronization in Visible Light Communication for Smart Cities," *IEEE Sensors Journal*, vol. 18, no. 5, pp. 1877-1886, 2018.

[15] Wang C., Zhang Z., Zhang M., and Zhu H., "Visible light Communication Application Scenarios Based on Android Smart Devices LED Lamp," *Photonic Network Communications*, vol. 32, no. 2, pp. 174-178, 2016.

[16] Wang Y., Chi N., Wang Y., Tao L., Shi J., "Network Architecture of A High-Speed Visible Light Communication Local Area Network," *IEEE Photonics Technology Letters*, vol. 27, no. 2, pp. 197-200, 2015.

[17] Zhou N., Wang J., and Wang Q., "A Novel Estimation Method of Metering Errors of Electric Energy Based on Membership Cloud and Dynamic Time Warping," *IEEE Transactions on Smart Grid*, vol. 8, no. 3, pp. 1318-1329, 2017.

Haider Al-Janabi (Member, IEEE) Get the B.S. degree in enginerring of Telecommunication systems and computers, from AL-Rafidain university college, Baghdad, Iraq, in 2011, and the M.S. degree in Engineering of Telecommunications systems and networks, from Kharkiv National university of Radioelectronic. And Ph.D degree from Odessa Acadimic of Telecommunications. His current research interests include Telecommunications systems, Computer Science Wireless Networks, QoS, and Traffic Engineering.

Hussam Al-Janabi was born in Baghdad, Iraq, in 1986. He received the B.S. degree in Computer communications Engineering form AlRafidain University College, in 2008, MSc degree in Telecommunication and Network Engineering from Kharkiv National University of radio electronics (KNURE), in 2010 and the Ph.D. degree in Telecommunication and Network Engineering, from Kharkiv National University of Radio electronics (KNURE), in 2013. His research interests are Wireless Communications, MIMO, WiMAX, LTE, Visible Light Communication, Control System, and Wireless sensor networks.

Bashar Qas Elias (Member, IEEE)received the B.S. degree in electrical engineeringfrom AL-Mustansiriya University, Baghdad, Iraq,in 2011, and the M.S. degree in electrical and electronicengineering from Eastern MediterraneanUniversity, Famagusta, North Cyprus, in 2014. Heis currently pursuing the Ph.D. degree in communicationengineering with the University of Perlis,Malaysia. His current research interests includemicrowave and millimeter-wave antennas, electromagneticbandgap and defected ground structures, microwave metamaterial,wearable antenna, and recongurable microstrip circuits.