ENGINEERING RESEARCH JOURNAL (ERJ)
Vol. 1, No. 42 October 2019, pp.82-87.
Journal Homepage: www.feng.bu.edu.eg

Design and Implementation of Indoor Optical Attocell via Visible Light Communication (VLC) Technique

M.Mohanna[1], Raafat A.EL-Kammar[2] M.Lotfy Rabeh[2], and Mohamed I.Gabr[3]

National Research Institute and Geophysics, Cairo, Egypt[1]
Faculty of Engineeringat shoubra, Benha University, Cairo, Egypt[2]
Al Safwa High Institute of Engineering, Cairo, Egypt[3]

Abstract: Wireless Communication using Visible Light is an exciting topic. This branch of communication has several advantages such that its infrastructure already existed and it can give extra data rate and security in data communication. In this paper design and implementation of a prototype VLC System that introduces point to multipoint communication is given. Experimental tests have been performed to verify the functionality of the system.

Keywords: Attocell, Visible Light Communication (VLC), Radio Frequency (RF),Optical Wireless Communication (OWC), Intersymbol Interference, Multipath link.

1. Introduction:

Wireless data traffic is growing dramatically. Recent predictions indicate that it will be a challenge to satisfy the data rate requirements of mobile users because of the limited Radio Frequency (RF) spectrum. Also, depending on the technological developments, the variety and quality of different devices used in communication process and applications running on these devices have increased rapidly. These high quality devices and applications require very high data transfer capacity and speed. Much of the internet transmission at the backbone is handled by optical fiber infrastructure that can achieve high data rate in order of Tera bits per second, nevertheless these high data speed is not received by the end users because it is difficult to install cable infrastructure to every point on a site or place, So the importance of wireless communication is increased day by day and is being used widely in homes, office, ….etc. Although wireless communication solved many problems like places where are difficult to install wired links and give easy operation. It brings a bottleneck problems where RF spectrum have been widely used in wireless communication so, the existing bandwidth can't satisfy the required capacity so scientists have focused on new technology used in wireless communication and after a great work, they introduced the Optical Wireless Communication (OWC) that has multiple advantages over RF communication like [1]:

- Unregulated 200 THz bandwidth.
- No licensing fee.
- Safe on human health.
- Consume low power energy.

Using infrared in communication is already used in (T.V remote control for example) but the latest researches have focused on achieving data transfer using LED lightening equipment. Common LED bulbs today consume 85% less energy than incandescent lamps. LED lightening market share with 40-50% (depending on geography) and 70% of global lightening market will stem from LED ships as early as 2020. In US [1], LED is expected to grow from 6% now to 60% in 2025 and to 90% in 2035. These cost effective LEDs devices are desired to be used in data transfer without using RF signals. The idea of data communication beside illumination using the same physical carrier is firstly reported by Nakajawa then IEEE gives a set of standards called IEEE 802.15.7 that were concerned with a short range wireless optical communication using visible light called Visible Light Communication standard (VLC). Finally in 2011, Harald Haas announced a new OWC technology called "LI-FI "or Light Fidelity at TED Global Lab. that using Light to transmit data [2-4]. During 20th century, almost all data were sent through air at frequencies lower than visible light band but today, light became an important carrier of data such as in fiber optics communication.

The main technological development that gives the VLC the opportunity to be popular technique or made the VLC possible is the High powered Light Emitting Diode (LED) of high quality as more advanced researches made on it to give higher data rate besides the infrastructure of the VLC system is already established in homes, public places, work and so on. So all we want is to replace the traditional bulbs by advanced and intelligent ones capable of transmitting data [5-6].

2. Basics of Visible Light Communication (VLC) System :

Visible light communication is the name given to an optical wireless communication system which carries

information by modulating the light in the visible spectrum that is mainly used in illumination using LEDs [7-8]. By this way lightening a room and data transfer will be achieved without the need to extra communication system. In other words, it is referred to an illumination source (light bulb) which besides to illumination can send information using the same light signal so, VLC = Illumination + Communication [9].

Consider a flash light used to send a certain signal which operated manually, this sends data using light signal but because it flashes on and off, it can't be a useful illumination source so it is not really VLC but consider it flashes at very high speed then we can't see the data and the flash light appears to emit constant light so we have illumination and communication.

The basic VLC configuration is given in figure (1),

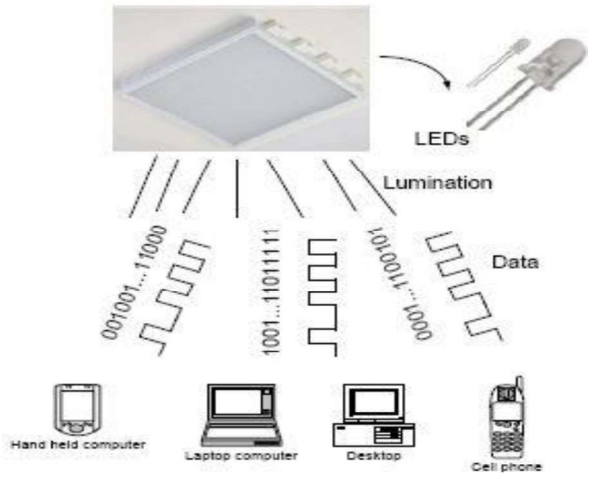

FIGURE 1. Basic VLC Configuration [1].

The fundamental architecture of VLC System are Transmitter (LED), Receiver (photo detector), Modulation Technique and the communication channel, as shown in figure (2),

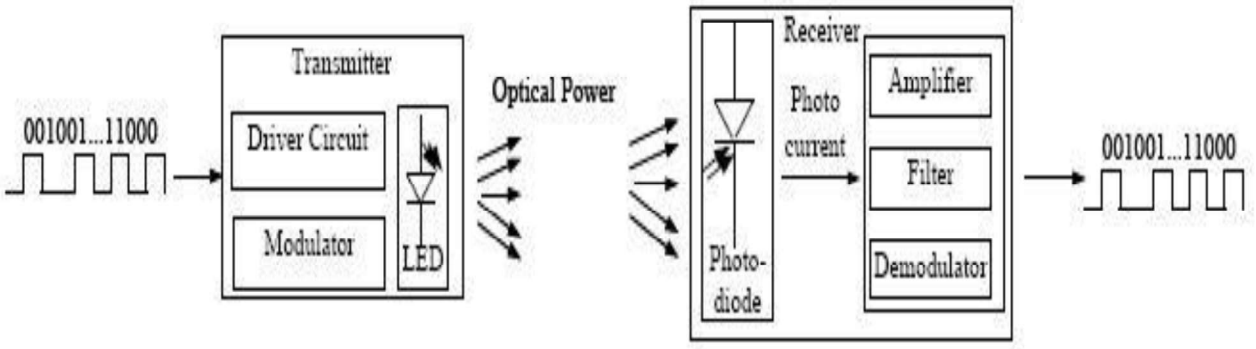

FIGURE 2. Block Diagram of VLC architecture.

2.1) Transmitter

There are different light sources that can be used for illumination however; Laser Diode (LD) and LEDs are the most common ones. The most popular of both is the LED [10-11]. Also the choice of modulation technique in the design of VLC system remains one of the most important issues. There are different types of modulation techniques [12-13] but the most widely used are On-Off Keying (OOK) and Pulse Position Modulation (PPM). On Off Keying is the oldest format and the simplest in terms of hardware implementation and integration.

2.2) Receiver

The photo detectors are the most component that absorb photons impinging on its front surface then generates an electrical signal. There are many types of photo detectors exist such as photomultiplier, phototransistor, photoconductors and photodiodes. The most common popular is the photodiodes due to their small size, high sensitivity, long operational life time and fast response.

2.3) Physical Design of VLC Link

It is one of the main challenges during the design of VLC [14]. It can be classified into two categories, named directed system and diffusive system. In directed system (Line of Sight), a narrow signal beam is established a point to point link between the transmitter and receiver that has a minimum multipath dispersion and give high data transmission rate. In the other side, in diffusive system (multipath link non line of sight signal), several multi path dispersion is existed due to the reflections from walls, ceiling, ground and other physical objects) that limits the communication band width and reduce the energy efficiency.

3. System Design:

A typical point to point VLC system is designed and implemented in [6], transmitting data from point to point (Simplex Communication Mode) using Hyper terminal program as an interface and MAX 232 IC but the bit rate was small , as shown in figure (3).

FIGURE 3. VLC using MAX 232 and Hyper Terminal Program [6].

3.1) Proposed system for point to multipoint VLC :

Another VLC system is designed and implemented to send data from point to multipoint (Half Duplex Communication Mode) with a block diagram shown in figure (4). Two receivers modules are used and because of the relatively low data rate, the intersymbol interference caused by multipath effect is not taken into consideration. Besides the hardware implementation, a VLC software suit is used to manage the transmitting and receiving processes. Arduino kit is used to control the data rate. By using this software, it is able to send different types of data like text files, videos, audio and photos by adjusting the operation modes at transmission mode. This software is mainly implemented based on Base 64 technique which is an encoding scheme i.e represent binary data as ASCII text using a numbering system consisting of 64 bits [15]. It uses (0 to 9, a to z, A to Z and + , /) in addition to (= sign) in some cases.

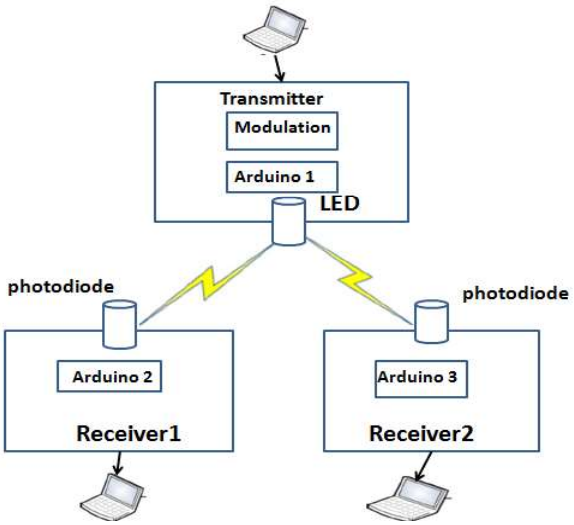

FIGURE 4. Our VLC System block diagram.

The minimum size of base 64 encoded string is 4 characters. If the source is not long enough to get these 4 characters, one or two equal signs are added for padding , so base 64 is usually contains a multiple of 4 characters ($4 - 8 - 12 - 16 - 20$ and so on). The following flowchart shown in figure (5) illustrates the encoding and decoding processes.

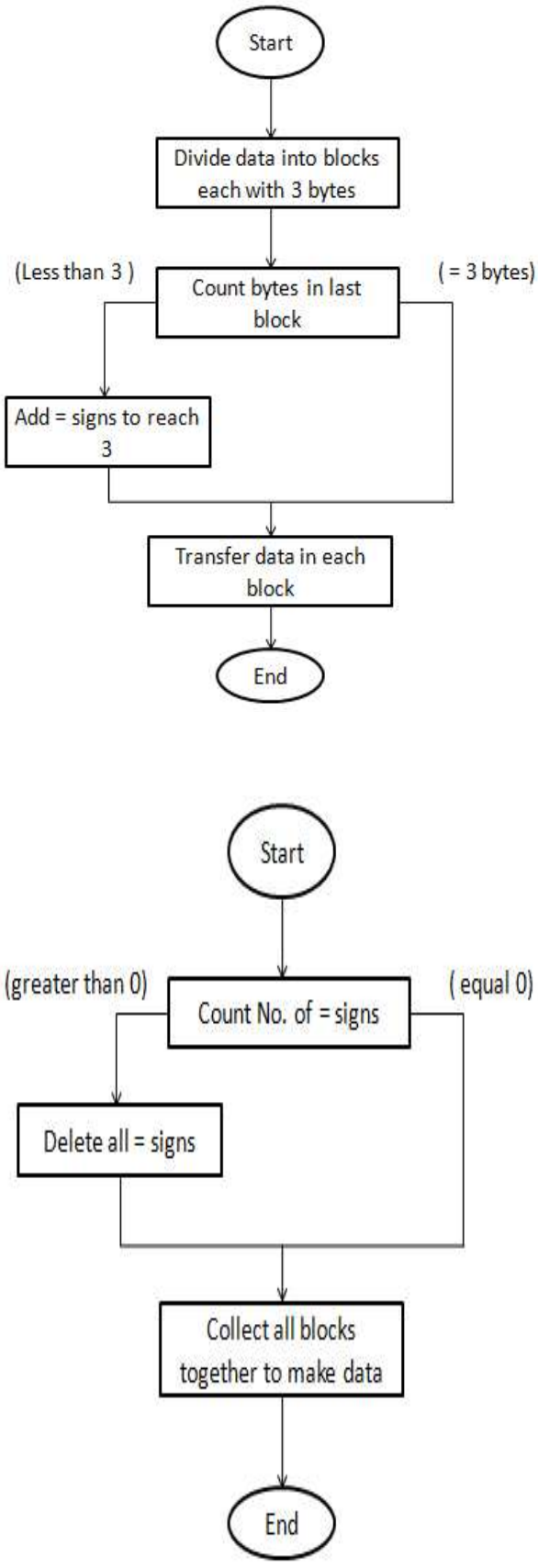

FIGURE 5. Encoding and Decoding processes.

3.2) At Transmitter:

The Light Emitting Diode (LED), one of the most popular light sources nowadays is used to transmit data after making a modulation technique on it. Here, On Off Keying (OOK) is used to make the modulation

process due to its simplicity rather than the other types. The choice of the transmission mode from the software interface and select the type of data (text- photos- ….and so on) and press on send button. The figure shown in (7) shows a text file contains **"Hello, it is a paper about Design and Implementation of Indoor Optical Attocell via Visible Light Communication Technique."** at the transmission mode interface after loading it.

3.3) At Receiver:

The first component in the receiver module is the photo detector which is a device used to detect light incident from LED light source and convert it to electrical signal. There are many types of photo detectors like photodiode, phototransistor and image sensor but the most popular and common device is the photodiode. Arduino kit is used again to manage and control the data rate at receiver end. In this design, there are two receivers' modules to make a simple communication network consists of one transmitter and two receiving nodes based on visible light communication technique. so, at both receivers, adjust the program to the receiving mode and select "start receive text" and then choose "save" as shown in figure (8).

4. Experimental Results:

4.1) Software User Interface:

Software developed was implemented using Visual C programming. By using it, different types of data can be sent like, text files, audio, photos and video. It was succeeded to transmit all these types except video file due to a problem occurred in the encoding process. The user interface of this program is shown in figure (6).

FIGURE 6. Software Interface.

To transmit any type of data, choose the desired type, for example **"text file"**, from the user interface and then adjust the software installed on the transmitter device on the **transmission mode** and load the desired file then send it as shown in figure (7) also, it is desired in future work to make an encryption on the transmitted data.

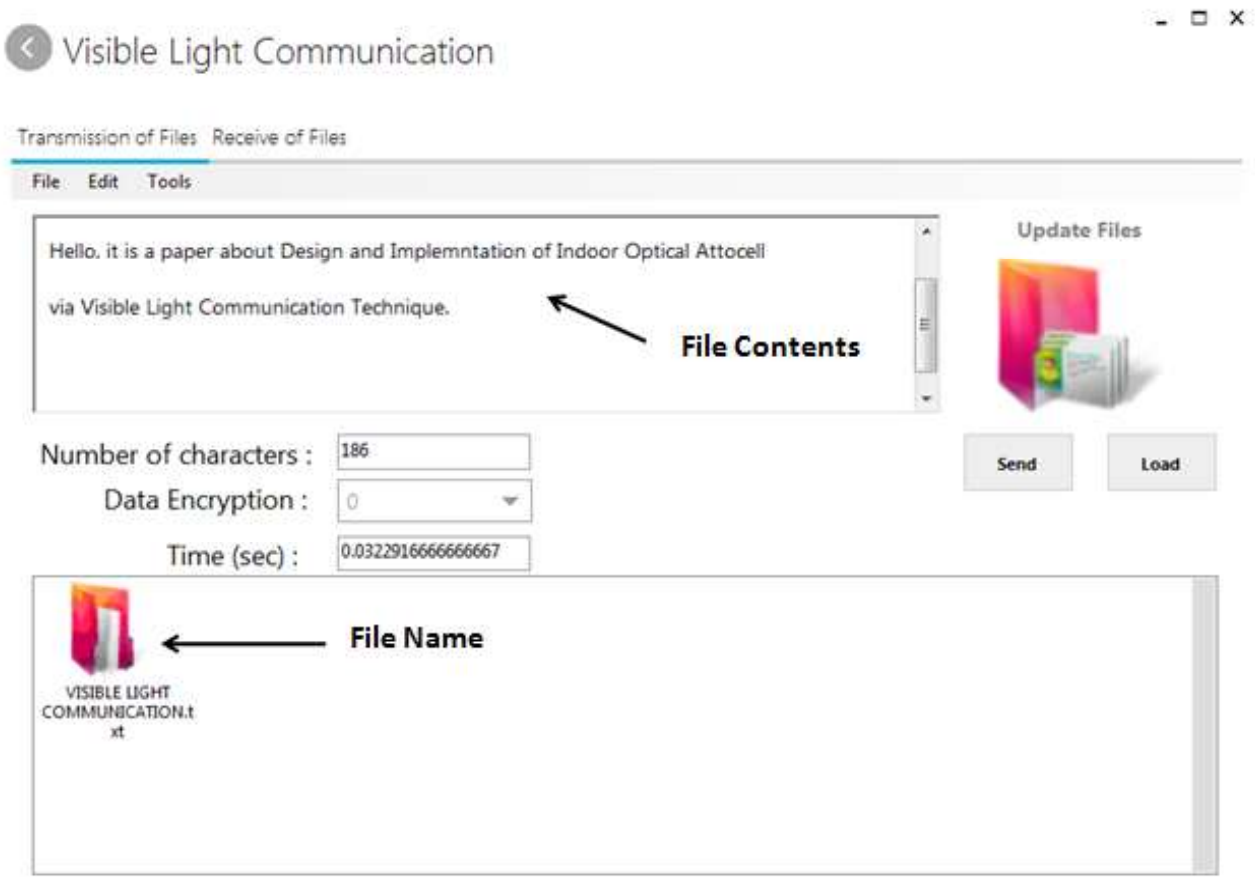

FIGURE 7. File transmission Interface.

At the receiver section, two receiving nodes are existed and ready to receive data as shown in figure (8). Here, adjust the software installed on the receivers on the **receiving mode** and wait for transmission and receiving processes. After receiving process is completed, the transmitted text file is shown in the text viewer and also the text file received can be saved for a later preview.

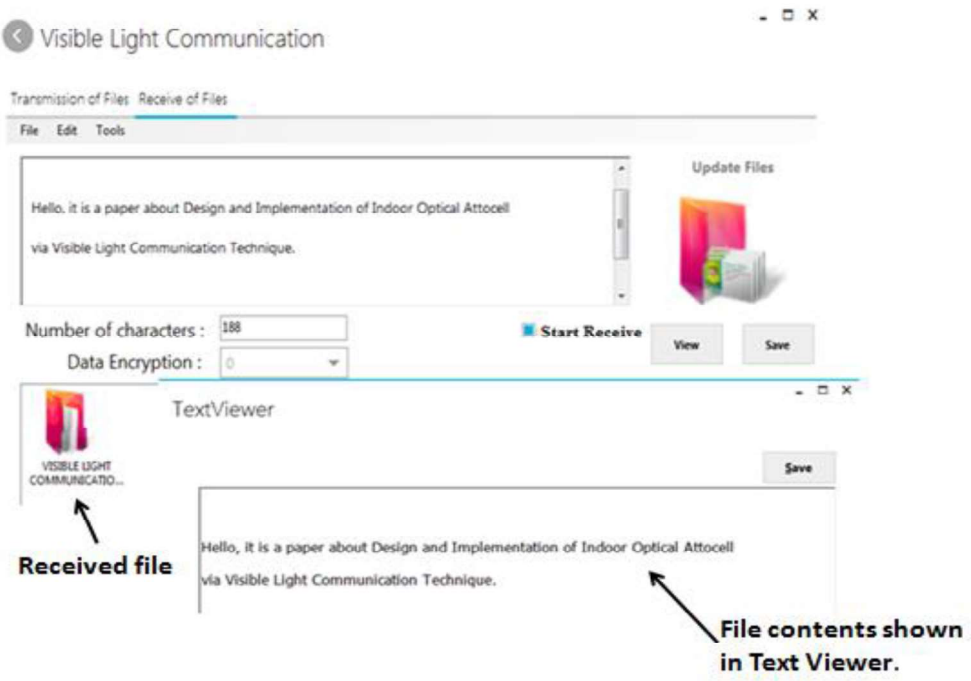

FIGURE 8. Receiving Interface and the received text file.

At the end, it was succeeded to transmit and receive a text file. The same process can be repeated to transmit different types of data.

4.2) practical Module:

In the lab, the design and implementation of the hardware for the optical Attocell based on VLC technique is performed as shown in figure (9), showing the different modules used, the transmitter module, receiver module 1 and receiver module 2.

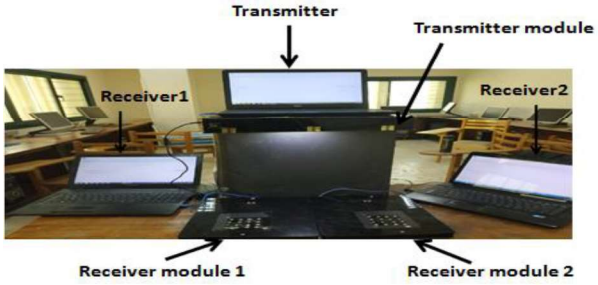

FIGURE 9. VLC System on the lab.

5. Conclusion:

Visible Light Communication (VLC) Technique has gained a great interest in the last decade because of the fast developments of the Light Emitting Diode (LED) industry. Long life time, efficiency and high switching speeds of LEDs make them excellent lightening device as well as an alternative cheap and fast data transfer equipment. So, it is possible to achieve illumination and data transfer simultaneously by using LEDs. By this way, both interior lightening of a room and data transfer are achieved without the need of extra communication system. The concept of VLC technique is demonstrated in this paper by designing and implementing a communication system capable of transmitting different types of data between a transmitter and two receiving nodes making a simple communication system based on visible light .

6. References:

[1] Taner Cevik and Serdar Yilmaz, "An Overview of Visible Light Communication Systems", International Journal of Computer and Communications (IJCNC),vol.7, No.6,November 2015.

[2] Ansury Sarkar and Shalabh Agarwal, "Li-Fi Technology: Data Transmission Through Visible Light", International Journal of Advanced Research in Computer Science and Management Studies", vol.3, Issue.6, June 2015.

[3] Yusuf Perwej," The Next Generation of Wireless Communication using Li-Fi (Light Fidelity) Technology", Journal of Computer Networks,vol.4, No.1, 2017.

[4] H.Haas," Wireless Data from Every light bulb", TED Website,Aug.2011.

[5] Hany Elgala, Raed Mesleh and Harald Haas, " Indoor Optical Wireless Communication: Potential and State of The Art", IEEE communication magazine, September 2011.

[6] M.lotfy Rabeh, Mohamed I. Gabr and Tarek Hosny, "Data Transmission via Visible Light Communication (VLC) Technique", International Journal of Innovative Research in Science, Engineering and Technology, vol.5, issue.9, September 2016.

[7] Christophe Jurczak, "LiFi: Enlightening Communications", arXiv:1802.01471v2 [physics.app-ph], 6Feb 2018.

[8] Harald Haas, "LiFi is a paradigm-shifting 5G Technology", Published by Elsevier, Reviews in Physics 3, (2018).

[9] http:\\ http://visiblelightcomm.com/what-is-visible-light-communication-vlc/.

[10] Y.Tanaka, T.Komine, S.Haruyama and M.Nakagawa," Indoor Visible Light Transmission System Utilizing White LED Lights",IEICE Trans, on Communications,vol.E86-B, No.8,Aug.2003.

[11] Mohamed Sufyan and Harald Haas," Modulation Techniques for LI-FI", ZTE Communications, vol. 14. No.2, April 2016.

[12] Puru Agawal and Manisha Kumawat, " An Overview On Visible Light Communication", IRE Journal, vol. 1, Issue 10, APR2018.

[13] Shiyan Yang," Research On Visible Light Communication Technology",2nd International Conference on Mechatronics and Information Technology (ICMT 2017).

[14] M.Mohanna, Raafat El-Kammar and Mohamed I.Gabr," Visible Light Communication (VLC) Channel Modeling", International Journal of Engineering Research in Computer and Engineering, vol.5, issue. 2, February 2018.

[15] Isnar Sumartono, Andysah Putera Utama Siahaan, Arpan, "Base64 Character Encoding and Decoding Modeling", International Journal of Rescent Trends in Engineering and Research, Volume 02, Issue 12; December – 2016.