Design and simulation of Li-Fi system transceiver

Khadija Rajab Alshari[1*], Hussain jobran Alfitore[2], Talal Tareq Alsharda[3], Mostafa Moftah AlAkele[4]

[1]Khadija.imdord@uob.edu.ly, [2]hALfitore97@gmail.com, [3]talaltareq5121105@gmail.com

[1] Electrical and Electronic Engineering Department ,Faculty of Engineering, University of Benghazi, Benghazi, Libya
*Corresponding author email: Khadija.imdord@uob.edu.ly

ABSTRACT

The communication system has developed rapidly through the recent years, and the increase within the bandwidth usage that led to its congestion specially in WiFi technique, it's paramount that's found an alternate or a faster means of communication. Light Fidelity is one technique that is used as competitive solution to WiFi, i.e, LiFi is one type of visible light communication that utilized the visible light to send data. In Li-Fi, the information is transmitted in several bit-streams through high-speed flickering of the LED bulb and decoded on the receiver side which consists of a photo detector. This happens within the sort of a binary transmission of knowledge, where '0' is that the LED in its 'offstate' and '1' is that the LED in its 'on-state'. In this paper, it has been designed and simulated a visible light communication system based on Li-Fi technology, that transmits an audio signal, rectangular signal and text. With the aid of Protues 8 and Multisim software programs in the simulation design circuits to send square wave signal and using Arduino to send text message. It has performed a wired circuit design to transmit an audio signal, in the receiver end it's tried to obtain the received signal with less distortion and enhancing the system performance.

Key words: Light Fidelity LiFi, Wireless Fidelity WiFi, VLC Visible Light Communication, Audio signal transmission, Text message transmission, square wave signal transmission.

Introduction

One of the most important daily activities is the transfer of data from one place to another. The current wireless networks that brought us to the Internet are very slow when connected to more than one device at the same time, thus fixed bandwidth makes it very difficult to enjoy high data transmission rates, connecting to a secure network, but radio waves, is only a small portion of the spectrum available for data transmission. A solution to the present problem was found by using Light Fidelity Li-Fi. Li-Fi means transferring data through light by sending data from an LED bulb that varies in intensity faster than the human eye will notice. Li-Fi, will discontinue the utilization of radio waves that are utilized by Wi-Fi technology. Li-Fi is cheaper and faster than Wi-Fi. [1] Li-Fi would use transceiver-fitted LED lamps which might light a section similarly as transmit and receive information. Since simple lights bulbs are used, there can technically be any number of access points. This technology uses a part of the spectrum that's still not greatly utilized- the colour spectrum Light is in spite of everything noticeably a component of our lives for immeasurable years and doesn't have any major ill effect [2]. Li-Fi as one of wireless systems are dealing through concatenation of the bandwidth. It offers an exponentially larger frequency band (up to 300THz) which can then be juxtaposed to that available in RF communications (up to 300GHz) [3]. Authors in Ref [4] used the concept of LiFi to transmit data to demonstrate the use-cases and the possible impact can have in the ever growing field of communication. The two types of data: Audio and Text were transmitted, also studied the various topologies to understand the characteristics a Li-Fi based system can have [4]. Researchers in Ref [5] proposed a whole model to transfer text, images from one device to another using visible radiation communication, which transmitter transmits the encrypted data through light and therefore the receiver at the receiving end identifies the transmitted data and decrypts it to retrieve the information sent [5]. As in Ref [6], Authors have designed a prototype of real-time audio and video broadcast system using inexpensive commercially available light emitting diode (LED) lamps. Experimental results show that real-time top quality audio and video with the almost distance of 3m and improvement of concentration effects. Lighting model within room environment is intended and simulated which indicates close relationship between layout of sunshine sources and distribution of luminance [6].

1. Materials and Methods:

Li-Fi may be a bidirectional, light based kind of communication offering high data transfer speeds. It utilizes light the way that radio waves are in Wi-Fi to transfer data wirelessly. Li-Fi employs lighting which is required by folks. Scientists are ready to achieve speeds as high as 224Gbps by keeping the device adjacent to a source of light. [3] Our work in this research is divided into three parts; one design is to send an audio signal and receive it with minimum distortion. The second part of design is to simulate a circuit that transmits a text from one point to another with the processing of Arduino UNO, with the aid of Proteus simulation to send a text message. The last one is accomplished using Multisim software to design a circuit to transmit and receive square wave signal. The results showed a system performance to receive the signal with minimum noise.

1.1 Audio signal transmission design

Data is transmitted by modulating the intensity of the light, which is then received by a solar panel or photo diode, and the light signal is demodulated into an electronic form. VLC consists of a light source as a transmitter and detector as a receiver. At the receiver side, a solar panel will receive the light signal and correspondingly generate an electrical signal that fed to a speaker produced the same audio signal that was sent, this is shown in figure 1. [10]

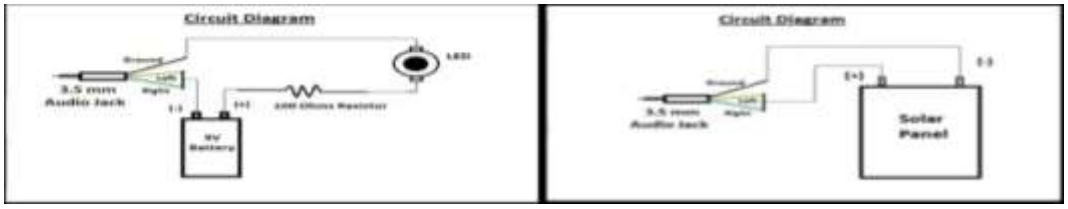

Figure 1. Circuit design of audio signal transmission (left), and signal reception (right)

1.2 Text message transmission design

In this part, the circuit is designed to transmit the text message using simulation by proteus software, the circuit diagram was built as shown in figure 2. The chosen text message "welcome to LiFi" will be sent from transmitter and processed through the arduino which is converted into digital stream. At the receiver the operation is reversed to decode the original message at LCD screen.

Figure 2. Simulated circuit design to transmit text message using LEDs.

1.3 Transmission design of special signals

a. Square wave signal transmission

A square wave signal will be transmitted using the circuit diagram shown in figure 3 with the aid of Multisim. The circuit consists of an array of LEDs to increase the luminous. During the design, We had a low resistance between the batteries and the LEDs to not short circuit the LEDs. The two 10Ω resistors in parallel to have the current from the batteries travel through a 5Ω resistance pathway to the LEDs. When the BJT turns on, the collector and emitter connect and the power from the batteries reach the LEDs. With the 2N2222A supporting high frequencies, the receiver needed a resistor to create a voltage difference with the photodiodes acting as a current source. the idea was to amplify the signal, and then We set up a simple non-inverting amplifier circuit to achieve that.[11]

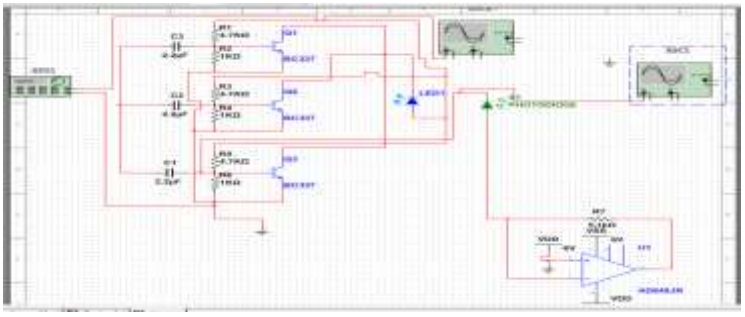

Figure 3. Design circuit to transmit square wave signal.

b. PWM signal transmission

Another type of signal is chosen to transmit is pulse width modulation PWM signal. The circuit design of overall system is shown in figure 4.

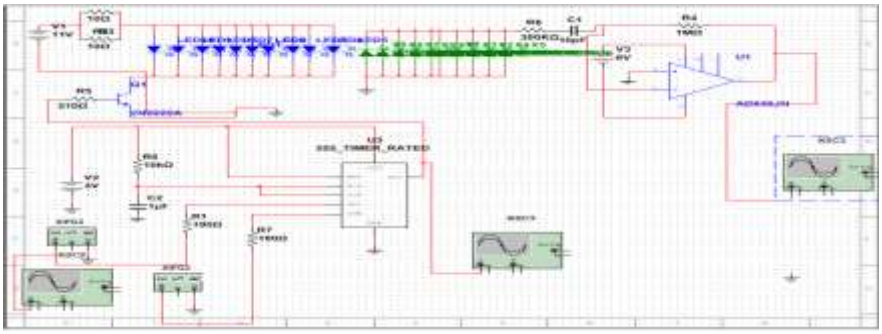

Figure 4. Design circuit to transmit and receive PWM signal using Multisim.

2. Theory and calculation

Figure 5 shows the visible light spectrum which uses the range from 400THz (780nm) to 800THz (375nm), as the information carrier. It is 10,000 times larger than a spectrum of Wi Fi, the spectrum provides the cheapest and largest available bandwidth (hundreds of THz) of existing RF. VLC networks are inherently safe as light does, they do not travel through walls. This allows for frequency

Reuse, and networks do not overlap one room and the next. The Electromagnetic interference and associated health Interests made VLC systems applied in places where wireless communication was Limited: hospitals, factories, underwater, laboratories, and Planes. [8]

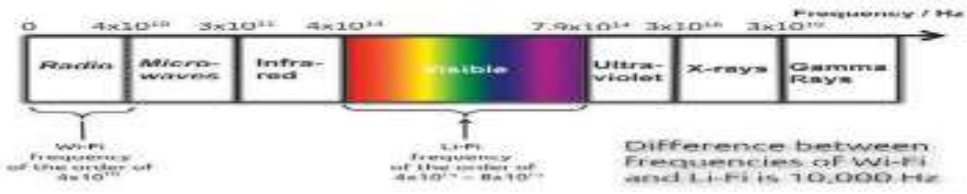

Figure 5. Electromagnetic Spectrum

In principle, LiFi also relies on electromagnetic wave for information transmission. Therefore, typically used modulation techniques in RF communication can be applied to LiFi with necessary modifications. Moreover, because of the employment of visible radiation for wireless communication, LiFi also provides variety of unique and specific modulation formats. Widely used single-carrier modulation (SCM) schemes for LiFi include on-off keying (OOK), pulse position modulation (PPM) and pulse amplitude modulation (PAM), which are studied in wireless infrared (IR) communication systems. For high-speed optical wireless communication, efforts are drawn to multi-carrier modulation (MCM). Compared with SCM, MCM is more bandwidth-efficient but less energy-efficient. One and maybe the foremost common realization of MCM in LiFi networks is orthogonal frequency division multiplexing (OFDM), where parallel data streams are transmitted simultaneously through a set of orthogonal subcarriers and complicated equalizer circuitry are often omitted. Each sub-channel may be considered as a flat fading channel. [7] Colour shift keying (CSK) is an IM scheme outlined in IEEE 802:15:7 where signals are encoded into color intensities emitted by red, green and blue (RGB) LEDs. In CSK, incoming bits are mapped on to the instantaneous chromaticity of the colored LEDs while maintaining with average perceived color. By combining different colors of light, the output data may be carried by the color itself and hence the intensity of the output will be near constant. Mixing of RGB primary sources produce different colors which are coded as information bits. The x-y chromaticity diagram shows the color space and associated wavelengths in blue text (units are nm) as shown in figure 6 [8] [9].

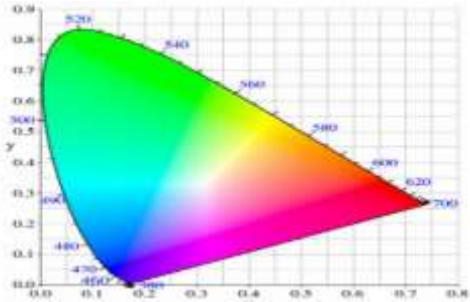

Figure 6. RGB LEDs that combines different wavelengths [8]

3. Results and Discussion

The circuit hardware of Audio signal transmission is shown in figure 7

Figure 7. wired circuit design of transmitter (left), and receiver (right).

After connecting the LiFi circuit, the music signal was sent from a mobile that is connected to 3.5mm jack at Tx. At the receiver, the sound was heard clearly. It's noticed that The color of LED used is affected to the received signal. Also as increasing the LEDs will receiving the signal by quality. So, It's suggested to increase the performance by using an array of LEDS. In addition the solar panel can be replaced by a photo diode due its sensitivity to the surrounding illumination that will receive signal with less noise. Moreover as increasing the distance between Tx and Rx will decrease the performance, as noticed in results the maximum distance to transfer an audio signal is about 5m. If there's a reflected plane around the light source, it will not scatter the beam of light, hence get max power at the receiver. Figure 8 shows the graph of system performance vs light intensity and distance.

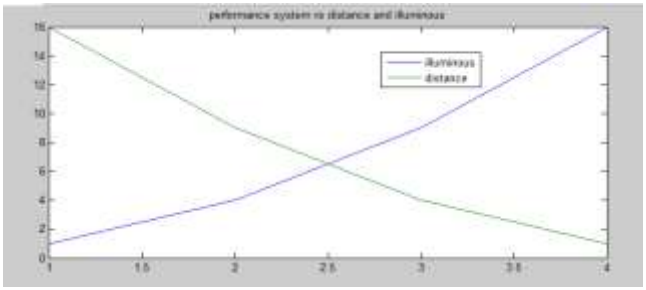

Figure 8. The graph of system performance vs distance and luminance intensity.

When sending a message, the transmission circuit Combines the code of the text in arduino, At the receiver, the LCD screen will display the result. If the message " Welcome to Li-Fi" was sent, the output will appear at LCD as shown in figure 9.

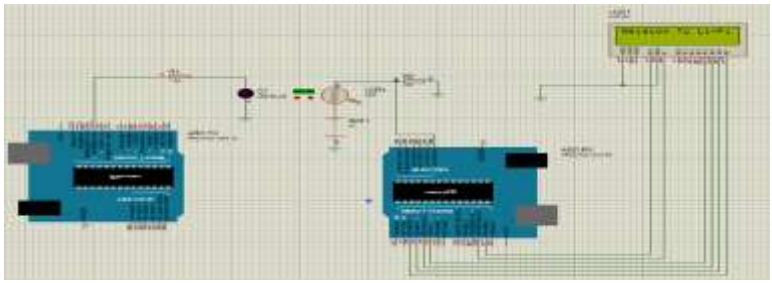

Figure 9. A text message "Welcome to LiFi" was sent and received on LCD.

Later, a square signal is chosen to be transmitted, it's noticed the received signal as shown on the oscilloscope of figure 10 with some distortion that may yield as a result of adjustment of some components in the design. Also for 2N222 for high frequency we get a signal with low noise.

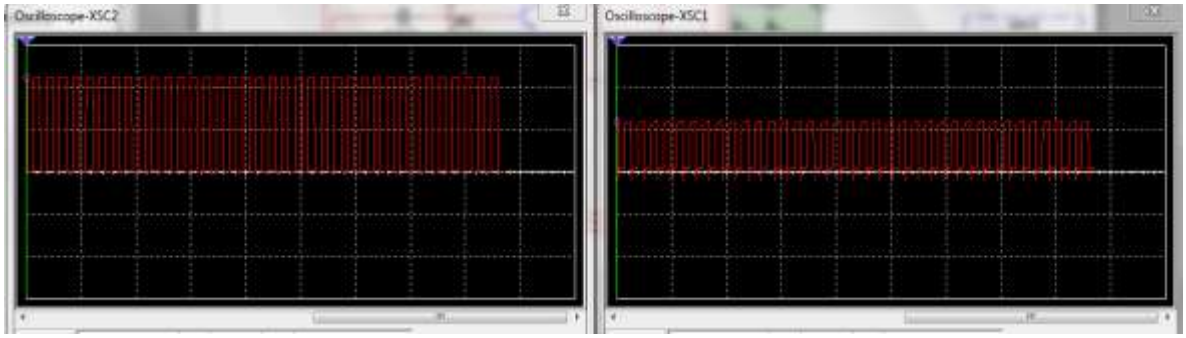

Figure 10. The transmitted signal (left) and the received signal (right)

In the last task of sending PWM, The result of the output signal is displayed on the screen of the oscilloscope is shown in figure 11. It's noticed distortion in the received signal, This can be eliminated by increasing the frequency and the amount of signal transmitted and the addition of operational amplifier in the reception circuit. More over some components like resistors and transistors will affect the output signal.

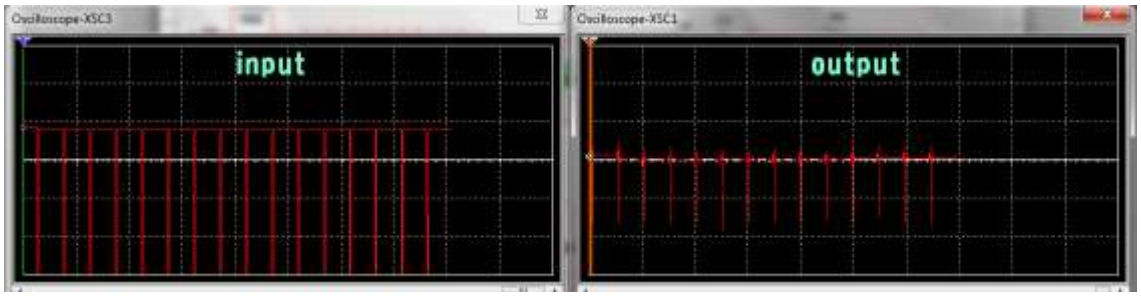

Figure 11. PWM transmitted signal (left) and the received signals (right)

4. Conclusion

Li Fi Technology is a method to transmit any signal from one point to another, it's considered as visible light communication, i.e, uses light to send data. Due to its high speed for transmission and its free bandwidth spectrum made LiFi more suitable and secure than WiFi. In this paper, the design of VLC communication system based on Li-Fi is operating with performance and can be received the original signal with minimum error. Three models of Li-Fi system were designed and simulated. In the first model, it's practically connected a circuit to send and receive an audio signal, that is transmitted through the LEDs, and received through the solar panel, the audio signal can be heard clearly using loud speaker. It's concluded the maximum distance to transmit reaches to about 5m. The other model is used to simulate a circuit to transmit a message signal from PC to

another with a help of Proteus design Software. Finally it will be able to transmit square wave and PWM signal using Multisim software and tried to receive a signal with low noise.

References

[1] R.Sanam , J.Srikanth , T. Sathis," A Study on Li-Fi Technology and Challenges in Connecting Devices", *International Journal of Innovative Research in Computer and Communication Engineering*, Website: www.ijircce.com Vol. 5, Issue 3, March 2017

[2] Phalguni Mookhopadhayay,"Li-Fi Technology", on LinkedIn, March 16, 2016.

[3] Prateek Gawande, Aditya Sharma, Prashant Kushwaha, "Various Modulation Techniques for LiFi", *IJARCCE International Journal of Advanced Research in Computer and Communication Engineering* ,Vol. 5, Special Issue 3, November 2016 Copyright to IJARCCE DOI 10.17148/IJARCCE 121

[4] A.Vinnarasi, S.T.Aarthy, "TRANSMISSION OF DATA, AUDIO SIGNAL AND TEXT USING LI-FI", *International Journal of Pure and Applied Mathematics*, Volume 117 No. 17 2017, 179-186. http://www.ijpam.eu

[5] Kosuri Siva Satyanarayana Raju, Velisetti Mohana Venkata Sai Deekshith , "PC to PC Transfer of Text, Images Using Visible Light Communication (VLC)",*International Journal of Advanced Engineering, Management and Science (IJAEMS)* [Vol-3, Issue-5, May- 2017]

[6] Yingjie He, Liwei Ding, Yuxian Gong, Yongjin Wang, "Real-time Audio & Video Transmission System Based on Visible Light Communication", *Optics and Photonics Journal*, 2013, (http://www.scirp.org/journal/opj)

[7] Harald Haas, Liang Yin, Yunlu Wang, Cheng Chen, "What is LiFi?", *JOURNAL OF LIGHTWAVE TECHNOLOGY JLT*, 2015 IEEE.

[8] Devanshu Jha , Chiragdeep Singh Malhotra, Abhishek Nanda, Moinuddin S. Savadatti, "The New Way of Communication", *Asian Journal of Applied Science and Technology (AJAST)* ,Volume 1, Issue 5, Pages 1-5, June 2017, www.ajast.net

[9] A. S. S. P. Rahul R. Sharma, "“Implementation of A Simple Li-Fi Based System”, *International Journal of Computing and Technology IJCAT* , Volume 1, Issue 9, October 2014.

[10] Revathi S, Aiswarya NJ ,SRM, "Audio transmission using Li-Fi", *International Journal of Advance Research, Ideas and Innovations in Technology*, (Volume 4, Issue 2), 2018, Chennai, TamilNadu

[11] Lifeng Lai,Shridhar Ambady,Megan Bredes, Calvin Nguyen, "Visible Light Communication" , Worcester Polytechnic Institute, March 26, 2015,