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A Light Fidelity (Li-Fi) Transceiver for Encoded Images

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ABSTRACT. In this paper a prototype Li-Fi transceiver isused to transfer a two dimensional (2D) image using UART serial communication from one PC to another PC using VLC. The Arduinos are used at both ends for controlling the overall data transmission process, and also they convert the data from ASCII string format to binary at transmitter side and vice versa the receiver side. Conversion is required to make data into a suitable file to be recognized by the PC software using Base64 encoding technique. In order to access the file and transmit it serially user interface (UI) is developed using C-Sharp (C#.Net). Thus the transmission of 2D image from one PC to other PC is carried out with Li-Fi technology using LEDs and phototransistors, with the data rate of 57600 bits per second, over a distance of one meter successfully using light as a transmission medium.

Keywords: Visible Light Communication (VLC), light fidelity (Li-Fi), personal computer (PC), two dimensional (2D).

1. INTRODUCTION

Li-Fi is one of the advanced and fastest technologies among other available data transmission technologies in the world of data communication. The high bandwidth and immunity to interference make it unique in areas where high data transfer is much required and other wireless technologies are restricted. It could be useful in variety of application including audio transmission, video transmission, text transmission and image transmission. Li-Fi communication is also called Visible Light Communication (VLC) since ituses visible light for transmitting the data from transmitter to receiver. Due to high bandwidth and interference immunity from electromagnetic waves, VLC is preferred over other available communication techniques. The basic idea is to send image as serial data using serial communication. To transmit the data, light emitting diodes are used at the transmitting end and phototransistors are used at the receiving end. LED light carries the data in the form of 1's and 0's by switching on and off the light at faster rates.

2. LITERATURE REVIEW

A Proposed system for transmitting data using Li-Fi technology via visible light as a communication method has been implemented[1]. This system used only for transmitting strings for short distances. The operational procedure is very simple-, if the LED is on, a digital 1 is transmitted, if it's off a digital 0 is transmitted.For transmitting datathe LEDs can be switched on and off very quickly, which gives nice opportunities. Hence to code data into those LEDs all that is required is some LEDs and a controller. Depending upon the data we want to encode we have to vary the rate at which the LED's flicker [2].One of the recently systems that having data transmission via Li-Fi technology using Raspberry PI[3],this system is prototype of real-time image broadcast system using LEDs. The Experimental results of this system show that a real time image with the maximum distance of 2ft can be achieved through proper layout of LED sources and improvement of concentration effects.

3. BASE64TECHNOLOGY

Base64 is an algorithm that uses a concept of modern encoding algorithms [4], but it does not an encryption method [5]. Base64 history begins with electronic mail. The email is sent by SMTP (simple mail transfer protocol) to a mail server, and then sent to the mailbox at the mail server destination. A Protocol is a set of rules and guidelines for communicating data between two computers via a network [6-8]. Base64 is used to encode the text, image and files;by knowing the table pattern of base 64 we can decode the message sent from destination to source. It cannot be the standalone communication encoding method; it might be combined with another encryption method to make the security level increases.Base64 is widely used on the Internet as an encoding method used to transmit data.

3.1 Usage

Base64 is commonlyusedin multiple applications like privacy Enhanced Mail (PEM), Multipurpose Internet Mail Extension (MIME), bit Unicode Transformation Format-7 (UTF-7), and open Pretty Good Privacy(OpenPGP) [4].

3.1.1 PEM

PEM protocol is the first protocol that uses base64 transformation techniques, based on RFC 989 in 1987, which consists of 7-bit characters .It is used by the mail server to transfer data using Simple Mail Transfer Protocol (SMTP). The current version of PEM used was based on RFC 1421, uses a 64-character alphabet consisting of upper and lowercase letters (A–Z, a–z), the numerals (0–9),and the + and / symbols.

3.1.2 MIME

MIME's Base64 encoding uses the same 64-character alphabet and encoding mechanism as PEMand uses the "=" symbol for output padding. MIME did not specify a fixed length for Base 64 encoded channels but specify a maximum length of 76 characters. Any alphabetical characters should be ignored by the decoder compatible, although most implementations use a pair CR / LF tolimit rows encoded. Thus, the actual length of MIME - compliant Base64encoded binary data is usually around 137% of the length of the original data, albeit for a very short message overhead can be much higher due to the overhead of the header. The final size Base64encoded binary data equal to 1.37 times the size of the original data + 814 bytes (for the header). In other words, the size of the data decoded can be estimate by equation (1) [9].

$$\boldsymbol{bytes = (string\_lenght(encoded\_string) - 814)/1,37} \quad (1)$$

3.1.3 UTF-7

UTF-7 Encoding isgenerally referred to as "Modified Base64". UTF-7 uses a character MIME base64, but do not use padding "=" Character. "=" is used as an escape character for encoding "quoted printable". UTF-7 is also used as a MIME header.

3.1.4 OpenPGP

OpenPGPuses a 64-radix encoding and it is referred to as "ASCII Armor" based on the technique of MIME encoding, but coupled with a 24-bit CRC checksum. The checksum value is calculated from the input data, before the encoding process. Base64 use the characters A - Z, a - z and 0-9 for 62 the first value, while the second last value is used for symbol (+ and /).

3.2 METHODOLOGY OF BASE 64

The transformation of Base64 is one of the algorithms for encoding and decoding data into ASCI format, which is based on the number 64. The characters generated from Base64 consist of upper and lowercase letters (A–Z, a–z), the numerals (0–9),and the + and / symbolsas shown in Fig 1.

The general steps to be done to complete the Base64 algorithm are [10]:

1. Look for the corresponding ASCII codefor each text.
2. Search binary number 8 bits of the ASCII code exist.
3. Combine the last 8 bits to 24 bits.
4. Broke a 24 bit earlier to 6 bits. It will produce four fractions.
5. Each fragment is converted into a decimal value.
6. Make value - the decimal value to an index to choose a character constituent of base64 and the maximum is 63 or 64 to the index.

Index	Char	Index	Char	Index	Char	Index	Char
0	A	16	Q	32	g	48	w
1	B	17	R	33	h	49	x
2	C	18	S	34	i	50	y
3	D	19	T	35	j	51	z
4	E	20	U	36	k	52	0
5	F	21	V	37	l	53	1
6	G	22	W	38	m	54	2
7	H	23	X	39	n	55	3
8	I	24	Y	40	o	56	4
9	J	25	Z	41	p	57	5
10	K	26	a	42	q	58	6
11	L	27	b	43	r	59	7
12	M	28	c	44	s	60	8
13	N	29	d	45	t	61	9
14	O	30	e	46	u	62	+
15	P	31	f	47	v	63	/

FIGURE 1. Base64 characters table.

4. LIGHT FIDELITY (Li-Fi) TRANSCEIVER SYSTEM

A VLC system is designed to achieve the concept of transceiver between the two devices.At the transmitter side, an image is converted into ASCII string format by using Base64encoding technique, Arduino is used for controlling the over flow data and converts the data from ASCII string format to binary at transmitter side and vice versa at the receiver side. A user interface (UI) is developed using C-Sharp (C#.Net)in order to upload the image and transmit it serially or recognize it at the receiver side [11]. Figure 2 illustrates the block diagram of the VLC Data transceiver systemusing UART serial communication[12]. Figure3shows the flow chartof encoding process on personal computer 1 (PC1). Figure 4shows the flow chartofdecoding process on other personal computer 2 (PC2).

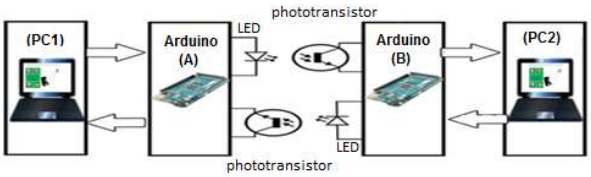

FIGURE2. Block diagram of transceiver VLC system.

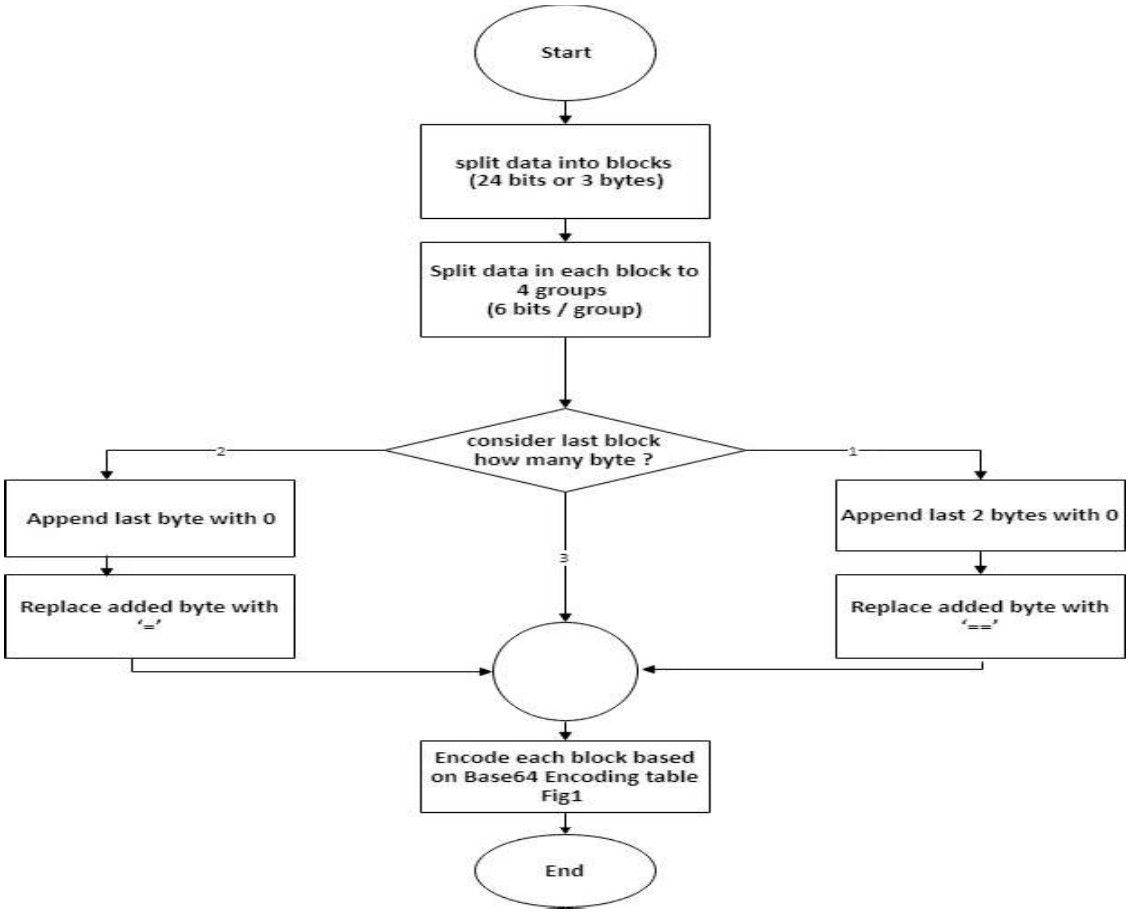

FIGURE 3. Flowchartof encoding process in transmitter side.

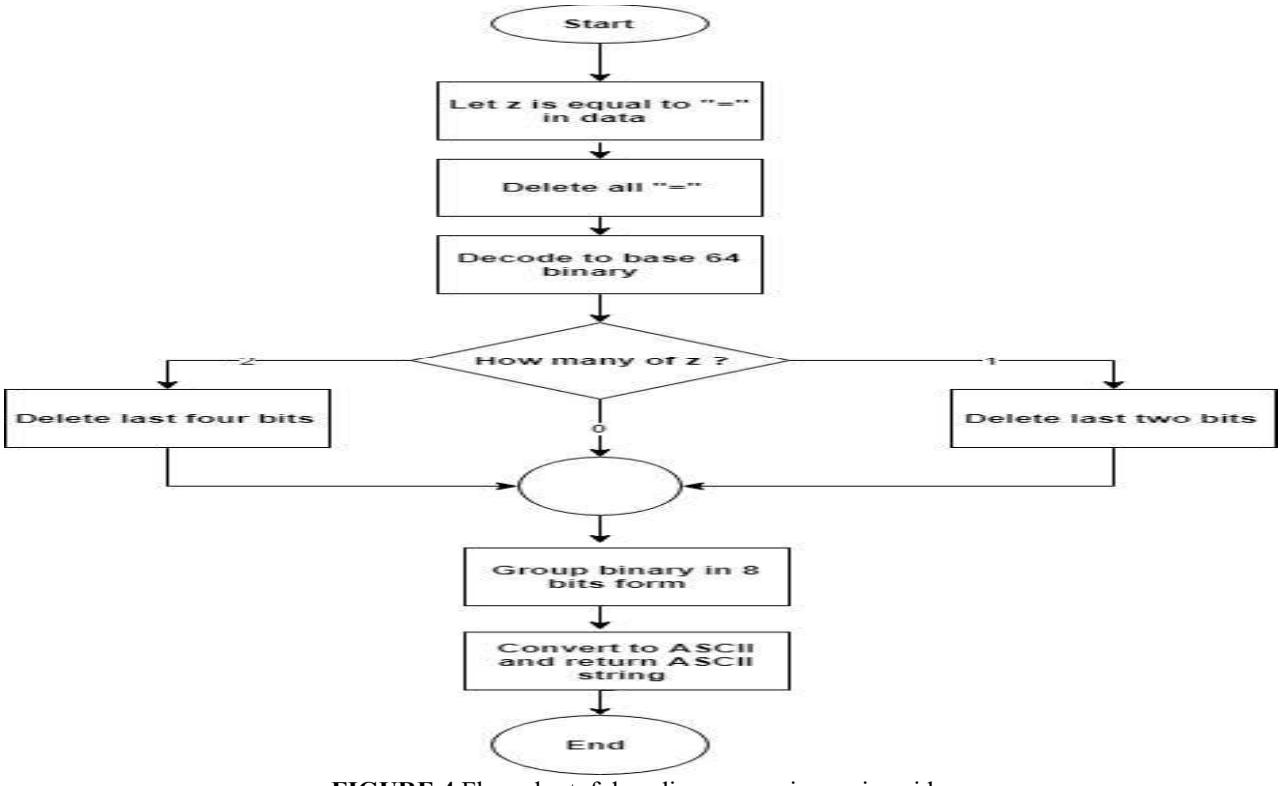

FIGURE 4. Flow chartof decoding processin receiverside.

5. EXPERIMENTAL RESULTS

The experimental setup was tested successfully and 2D image with extension PNG was sent from one computer to another computer using Li-Fi technology.The maximum distance between transmitter and receiver is one meter to achieve successful transmission and Line of sight is always required. Using high speed LED's with higher power, the transmission distance between transmitter and receiver can be increased to five meters. The experimental setup forVLC system is shown in Fig 5.

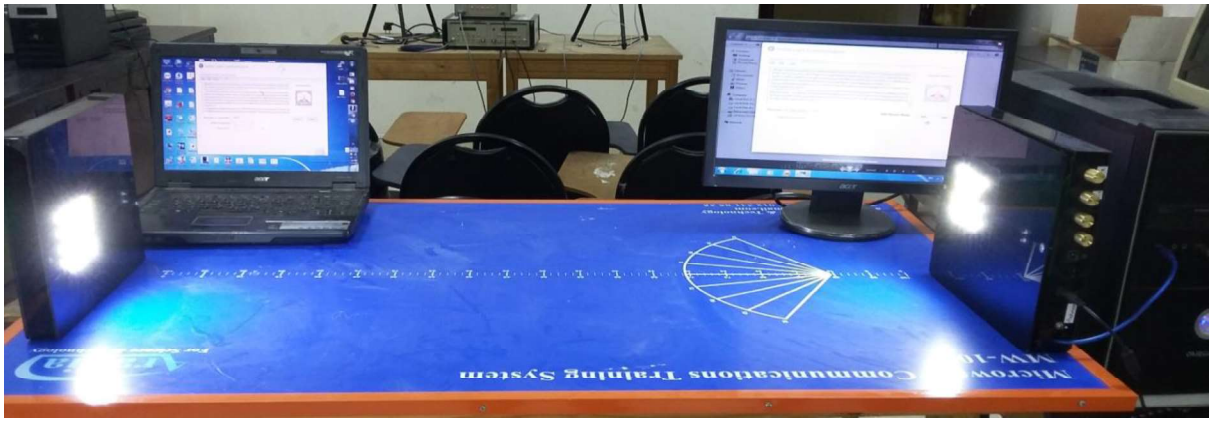

FIGURE 5. The experimental setup forVLC system.

For successful transmission of image between transmitter and receiver the following steps are performed:

- The 2D image which is already available in the PC 1 is selected by the user,once clicking on load buttonshown in Figure6the image Encoded into base64 representation formats.
- After encoding the image, click on Send buttonshown in Figure6, the process of sending an encoded image from transmitter side is done by the software to Arduino serial port.
- At the receiving end, the image is received in encoded form via phototransistor.
- Once clicking on view button provided in UI the user will get original 2D image that transmitted from transmitter side as shown in Fig 7.

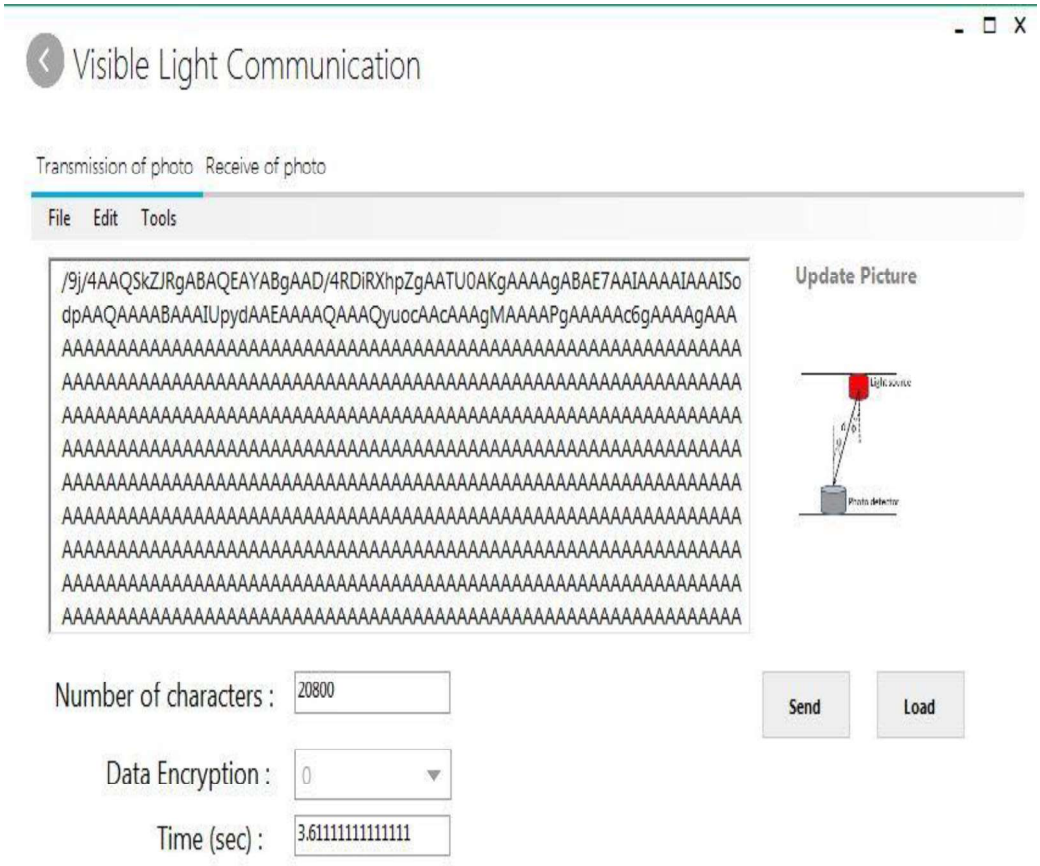

FIGURE6. Encoding the image into base 64 representation in transmitter side.

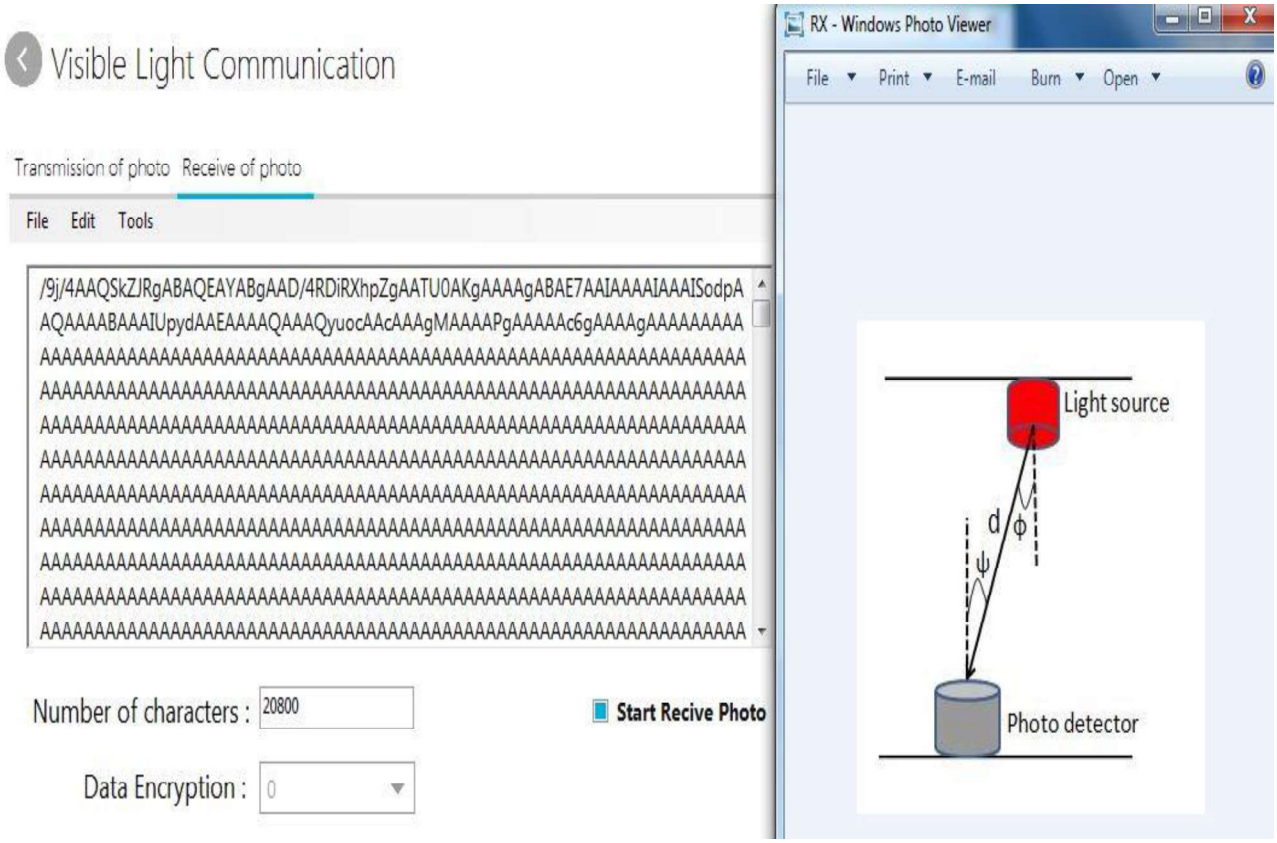

FIGURE7. Decoding theimage in the receiver side and previewing.

The number ofbit errors per unit time is measured using Bit Error rate (BER). BER is the ratio between numbers of error bits to the total number of transferred bits over the studied time period. BER is a unit less quantity, often expressed as a percentage. Coding and modulation techniques are related to the BER performance. The simple and power efficient On-Off Keying (OOK) is adopted in this prototype. It is a binary level modulation scheme consisting of two symbols. Considering ones and zeros are equally likely, the BER can be determined by equation (2) [13] while the OOK BER error probability can be determined by equation (3) [14].

$$BER = \frac{\text{Number of error bits}}{\text{Number of bits transmitted}} \quad (2)$$

$$p_{error-ook} = Qfunc\left(\sqrt{\frac{E_b}{N_o}}\right) \quad (3)$$

Figure 8 illustrates the theoretical OOK BER error probability with the simulated one.

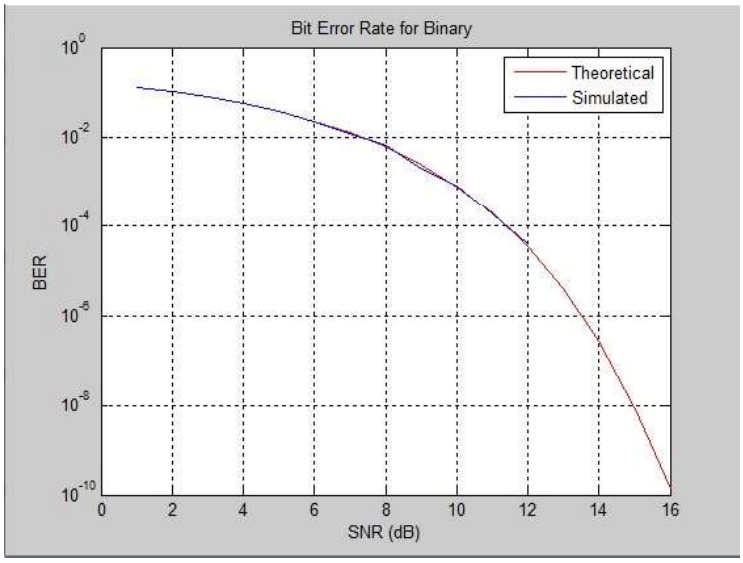

FIGURE 8. Theoretical OOK BER with the simulated one.

6. CONCLUSION

The transceiver that is introduced in this paper can be put into practical use, every PC can be used something like a Li-Fi transceiver to transmit wireless data to a number of other PCs and proceeding toward the cleaner, greener, safer and brighter future. Compared with the traditional radio-based system, the new Li-Fi concept is attracting a great deal of attention because it can offer very efficient and genuine. With increasing demand of wireless internet connection, the airwaves are becoming increasingly clogged, making it difficult to obtain reliable and high-speed data signals. Li-Fi technology may solve problems such as the shortage of radio-frequency bandwidth and it can also allow internet where radio based wireless communication system isn't allowed such as in aircraft or in hospitals. One of the limitations however is Line of sight is always required for successfully transmission.

7. FUTURE WORK

In future, theUI will be enhanced with button able to encrypt anddecrypt thedata to be more securedas no password or key in Base64 algorithmanddesigning access point able to transmit data to end points as well as trying to increase the bit rate of the transmitted data.

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