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Performance Analysis of VLC System for NRZ And Rz-Ook Modulation Technique by Using Mach-Zehnder Modulator

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ABSTRACT

With the radio frequency spectrum becoming crowded, an alternative means to wireless communication is necessary to accommodate the exponentially increasing wireless traffic demand. By employing light from LEDs as the communication channel, visible light communication systems provide an alternative to the present norms of wireless information transport. The optical transmitter in these systems blinks quickly enough that the human eye will not notice the change in light intensity, but an optical receiver can detect the on-off behaviour and decipher the information contained within. In this paper we have analyzed the performance of visible light communication using mach zhender modulator for RZ-OOK and NRZ-OOK modulation formats. We have implemented WDM (Wavelength Division Multiplexing) channel for various streams of data. The Quality Factor and log of BER values for various data rates and link distances are used to evaluate the communication system. With a maximum Q factor of 46, this system can provide 2 Gbps data throughput across a connection distance of up to 2500 m. The communication is conducted via an optical transmitter, and NRZ-OOK and RZOOK modulation studies are conducted.

Keywords : Zhender Modulator , NRZ-OOK, RZ-OOK,

I. INTRODUCTION

A wireless technique called visible light communication (VLC) allows for the rapid transport of data using visible light. Modulating the intensity of light emitted by a light source allows for the transmission of this data (or any optical transmitter). An optical receiver, such as a photodiode, receives the signal and converts it into legible and easily consumable forms for end users. This often refers to the full electromagnetic spectrum, which ranges from gamma rays to radio waves, when discussing light. The term "visible light" refers to that fraction of the electromagnetic spectrum that is

Visible to the human eye. When compared to systems that employ radio frequency, the use of visible light for data transfer has a number of major advantages. Its major benefit is that the visible light spectrum is 10,000 times bigger than the radio spectrum, which is likewise overused and overcrowded and has a smaller bandwidth. The huge expanse of the visible light spectrum, which provides 300 THz of license free bandwidth carried on visible wavelengths, makes VLC a realistic choice, especially given that mobile traffic is predicted to expand sevenfold by the year 2021. In addition to the visible light spectrum's vastness, light travels at a speed of 186,000 miles per second, which is far quicker than radio waves' airborne speed of 344 metres per second. When compared to systems that employ radio frequency, the use of visible light for data transfer has a number of major advantages. Its major benefit is that the visible light spectrum is 10,000 times bigger than the radio spectrum, which is likewise overused and overcrowded and has a smaller bandwidth. The huge expanse of the visible light spectrum, which provides 300 THz of license free bandwidth carried on visible wavelengths, makes VLC a realistic choice, especially given that mobile traffic is predicted to expand sevenfold by the year 2021. In addition to the visible light spectrum's vastness, light travels at a speed of 186,000 miles per second, which is far quicker than radio waves' airborne speed of 344 metres per second.

HISTORY OF VLC

The development of the picture phone, which sent voice over several hundred metres of modulated sunlight, by Scottish-born scientist Alexander Graham Bell in the 1880s in Washington, D.C., marks the beginning of visible light communications (VLC). This was done before radio speech transmission. At Keio University in Japan's Nakagawa Laboratory, more recent work utilising LEDs to transfer data using visible light started in 2003. Since then, there have been a lot of VLC-related research projects. In order to enable broadband connectivity for indoor applications, researchers from CICTR at Penn State suggested combining white light LED with power line communication (PLC) in 2006 [1]. According to this study, VLC may someday be used as the ideal last mile option. In January 2010, a group of researchers from Siemens and the Fraunhofer Institute for Telecommunications at the Heinrich Hertz Institute in Berlin showed that a white LED can transmit data at 500 Mbit/s over a 5-meter (16-foot) distance and at 100 Mbit/s over a longer distance [2]. The IEEE 802.15.7 working group is responsible for conducting the VLC standardization process. 2010 December St. Cloud, Minnesota, the first commercial application of this technology, inked a deal with LVX Minnesota. TED Global hosted a talk in July 2011. Gave a live demonstration of HD video being communicated via a regular LED light source and suggested the moniker "Li-Fi" to describe a subset of VLC technology. Indoor positioning systems based on VLC have gained popularity recently. According to ABI research, it may hold the key to opening up the $5 billion "interior location market." Nakagawa Laboratory has been publishing articles, while Byte Light has filed a patent. On an LED digital pulse identification light placement system in March 2012[4] [5]. Researchers from COWA at Penn State [6] and other institutions worldwide [7] [8]. Due to its cheap cost and complexity implementation, which only needs one microcontroller and one LED as the optical front-end, toys are another new application [9]. Security can be offered by VLCs [10] [11]. They are particularly helpful in personal area networks and body sensor networks. Recently, VLC communication lines up to 10 Mb/s have been built using Organic LEDs (OLED) as optical transceivers [12]. Axrtek released the MOMO commercial bidirectional RGB LED VLC system in October 2014; it has a range of 25 feet and transmits down and up at a speed of 300 Mb/s. At order to provide VLC location-based services to customers' smartphones in a hypermarket in Lille, France, Philips teamed up with the grocery chain Carrefour in May 2015 [13]. Two Chinese businesses, Kuang-Chi and Ping a Bank, joined together in June 2015 to launch a payment card that transmits data using a special visible light [14Philips launched the first VLC location-based services for customers' cellphones in Germany in March 2017. The piece was shown at Düsseldorf's Euro Shop. The technology is being used by an Edeka supermarket in Düsseldorf-Bilk as the first supermarket in Germany. It can reach positioning precision of 30 cm, which fits the unique requirements in the food retail industry. VLC-based indoor positioning systems may be used to find people and steer indoor robotic vehicles in settings including hospitals, nursing homes, warehouses, and big, open workspaces. Indoor positioning systems based on VLC have gained popularity recently. According to ABI research, it may hold the key to opening up the $5 billion "interior location market Nakagawa Laboratory has begun releasing publications, and Byte Light has applied for a patent. 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SYSTEM MODEL

2.1 MODULATION FORMAT

We have used two modulation technique: RZ-OOK modulation and NRZOOK modulation. 2.1.1 NRZ-OOK modulation the transmitter section of our system is shown in Figure: 1(a) and Figure: 1(b). In this section, we have four sub-system. Each of these subsystem contains Continuous Wave (CW) LASER, NRZ pulse generator, MZ modulator and some measurement tools to measure various parameters to analyze the results. In each subsystem Continuous wave (CW) laser that generates a continuous wave optical signal, Mach Zehnder Modulator which controls the amplitude of the optical wave and converts the binary input into an optical signal, PRBS (Pseudo Random Bit Sequence generator) which generates a random bit stream of data, NRZ pulse generator which maps the binary signal to be transmitted as logic 1 to a high level and logic 0 to a low level and an optical amplifier to improve the quality of the signal being transmitted. A fork is connected to the output of WDM multiplexer which is used to duplicate the input beam. The multiple laser beams from the fork are then combined using a power combiner and the output from the power combiner is propagated through the transmission channel of FSO. An optical adder is used to sum up two optical signals which add the amplitude of the two input signal.

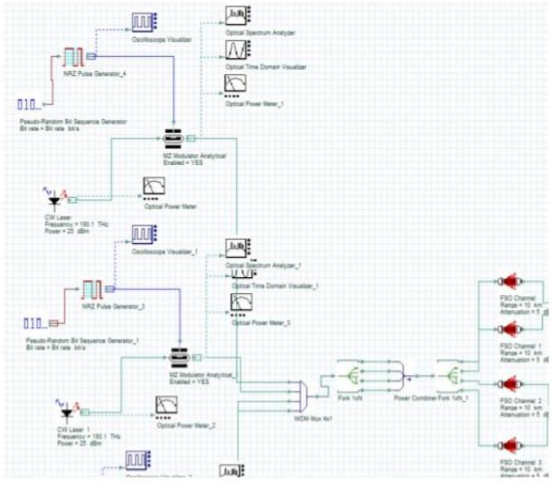

Figure:1(a)

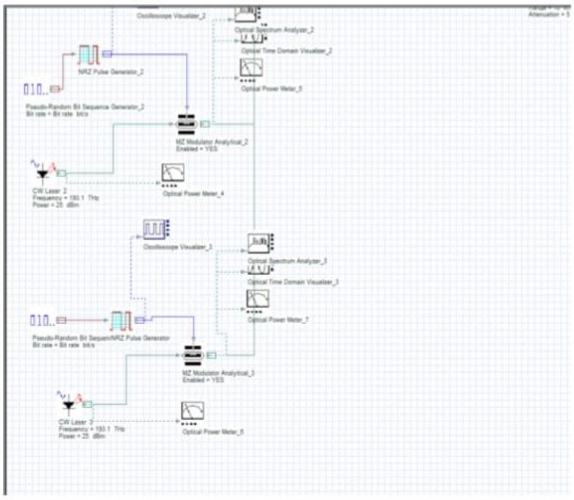

Figure:1(b)

The receiver section is shown in figure: 1(c) and figure: 1(d) consists of a WDM DE multiplexer that has the similar specifications as that of the WDM multiplexer used. DE multiplexer is used to divide the signal corresponding to its wavelength. A subsystem is used at every port of DE multiplexer in the receiver end which comprises of components such as detector, filter, 3R Regenerator and a BER analyzer. Then a detector (optical receiver) is used which is one of the basic component in the receiver section that converts the optical signal to an electrical signal. A 3R Regenerator is then used which performs operations such as reshaping, retiming and amplification of the data pulse. A low pass Bessel filter is used which allows only the signals at a particular range of frequencies. Finally, an analyzer named BER analyzer is used to measure the parameters like minimum BER, maximum quality factor, eye height and threshold value.

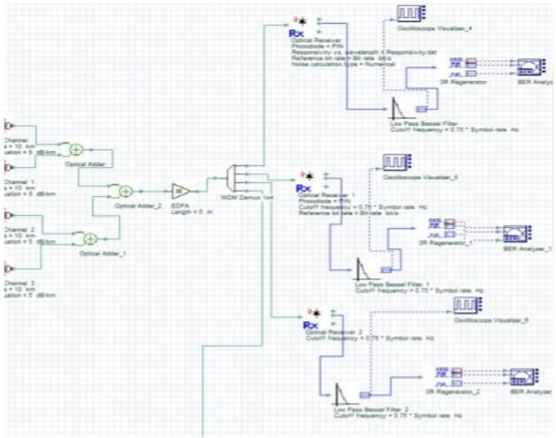

Figure:1(c)

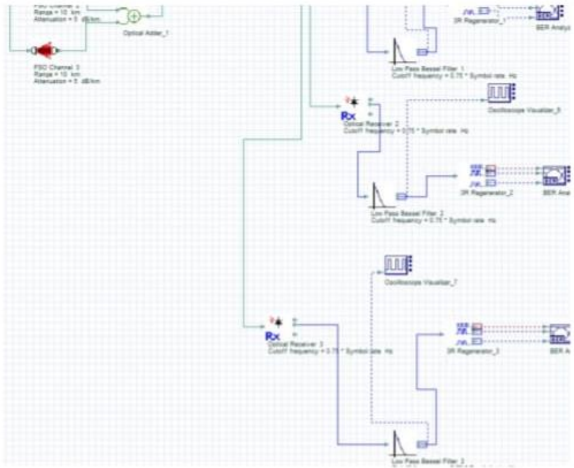

Figure:1(d)

2.1.1 RZ-OOK

Modulation The transmitter section of our system is shown in Figure: 2(a) and 2(b). In this section, we have four sub-system. Each of these subsystem contains Continuous Wave (CW) LASER, RZ pulse generator, MZ modulator and some measurement tools to measure various parameters to analyse the results. In each subsystem Continuous wave (CW) laser that generates a continuous wave optical signal, Mach Zehnder Modulator which controls the amplitude of the optical wave and converts the binary input into an optical signal, PRBS (Pseudo Random Bit Sequence generator) which generates a random bit stream of data, RZ pulse generator which maps the binary signal to be transmitted . A fork is connected to the output of WDM multiplexer which is used to duplicate the input beam. The multiple laser beams from the fork are then combined using a power combiner and the output from the power combiner is propagated through the transmission channel of FSO.

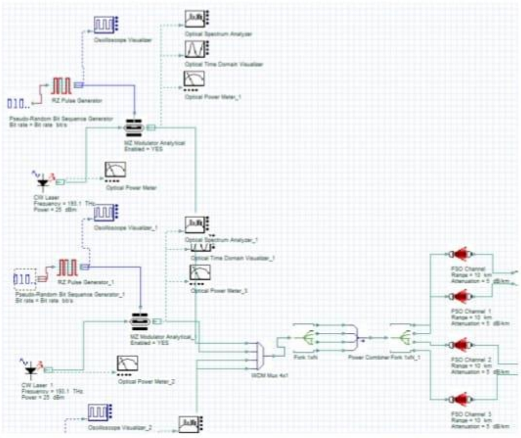

Figure:2(a)

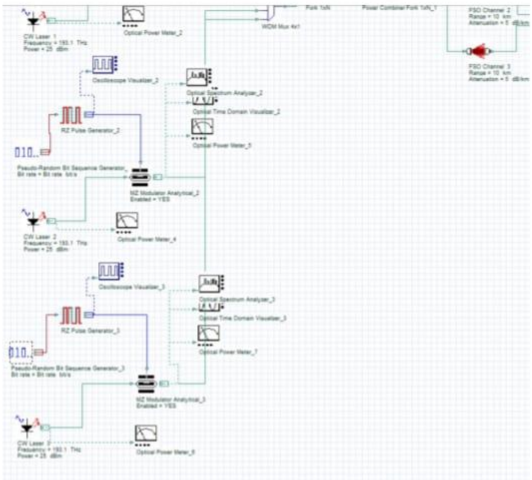

Figure:2(b)

RESULT AND DISCUSSION

3.1 NRZ-OOK MODULATED SIGNAL ANALYSIS

For the deigned VLC system the white LED having the bandwidth of 300 nm at centre frequency of 550 nm. The designed system is analysed for different bitrates along with different link distance in meter. Here, initially the NRZOOK modulated signal is taken for analysis. Figure: 3(i) depicts the Q factor of the detected signals for the bitrate variation from 400 Mbps to 2 Gbps with respect to the link distance up to 2500 m. From results, it has been found that our simulated VLC system could support 2 Gbps with an optimum Q factor 42 at link range 2500 m, beyond which the received signals tend to become degraded. At the bit rate of 400 Mbps, our designed system provides the superior performance of about Q factor whose value of 257 for the link range below 1000 m. And for the same bit rate, maximum transferable distance is obtained as 3000 m with Q factor 20.1. Figure: 3(ii) also confirms that our VLC systems could support 2 Gbps up to the link distance of 2500 m, and found log of BER -3.11.

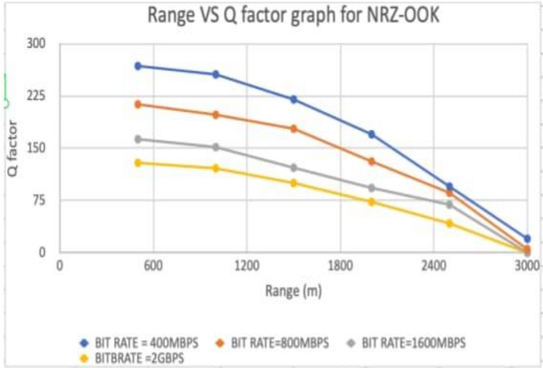

Figure:3(i)

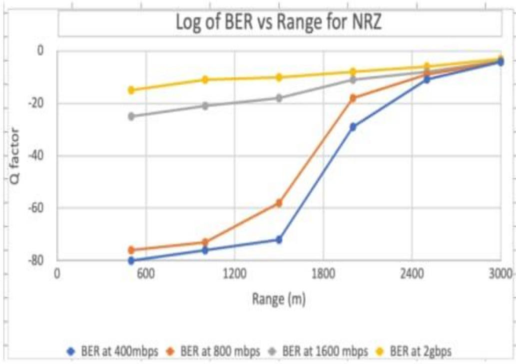

Figure:3(ii)

3.2 RZ-OOK MODULATED SIGNAL ANALYSIS

In our designed VLC system there is a very little difference in results of RZOOK modulation and NRZ-OOK modulation. RZ-OOK modulated signal shows slightly better result than NRZ-OOK modulated signal. Figure: 3(iii) depicts the Q factor of the detected signals for the bitrate variation from 400 Mbps to 2 Gbps with respect to the link distance up to 2500 m. From results, it has been found that our simulated VLC system could support 2 Gbps with an optimum Q factor 46 at link range 2500 m, beyond which the received signals tend to become degraded. At the bit rate of 400 Mbps, our designed system provides the superior performance of about Q factor whose value of 260 for the link range below 1000 m. And for the same bit rate, maximum transferable distance is obtained as 3000 m with Q factor 21. Figure: 3(iv) also confirms that our VLC systems could support 2 Gbps up to the link distance of 2500 m, and found log of BER -6.9.

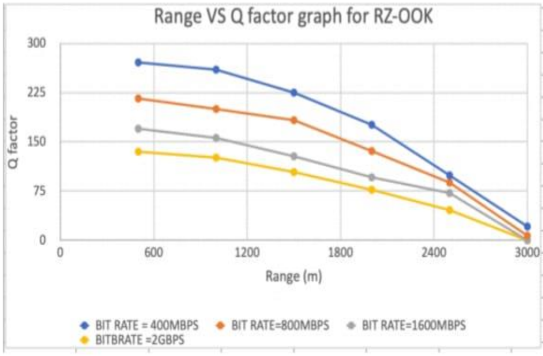

Figure:3(iii)

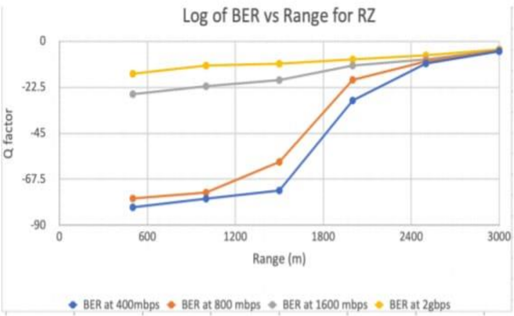

Figure:3(iv)

Figure: 4(a) and figure: 4(b) represent the eye diagrams of one BER Analyzer of each NRZ-OOK modulation format and RZ-OOK modulation format respectively. These eye diagrams are at bit rate of 2 Gbps at link range of 2000 m. Although there is a difference in the results of RZ and NRZ modulation, but the difference in the result are very less, that is why the eye diagram for both the modulation format almost look similar (there is a very little difference in the eye heights).It clearly depicts that at bitrate of 2gbps the signal can reach up to 2000 meter link distance with good eye

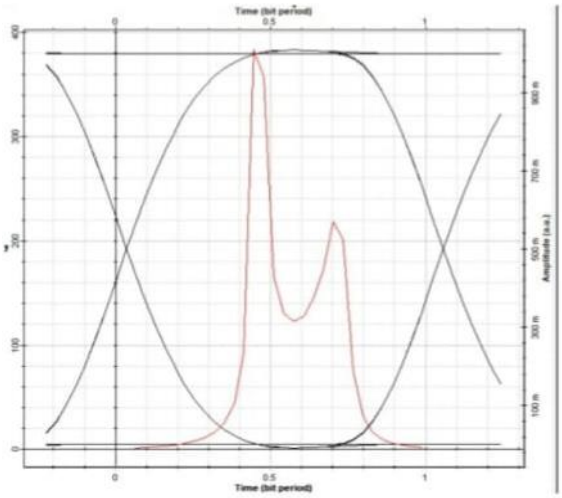

Figure :4(a) BER Analyzer for NRZ-OOK modulation

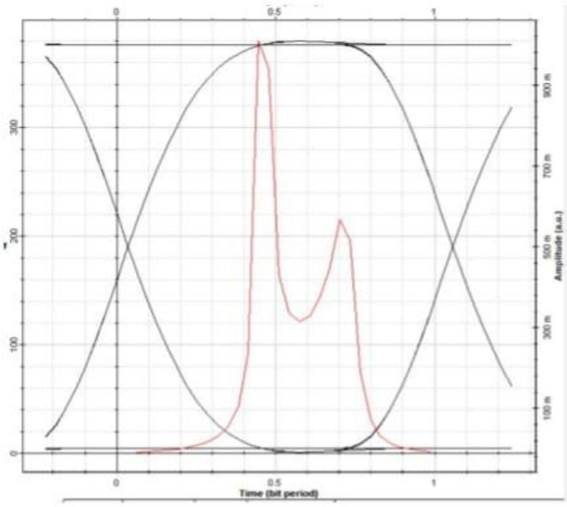

Figure:4(b) BER Analyzer for RZ-OOK modulation

CONCLUSION

We have proposed a study of Visible Light communication for LASER with MZ modulator in WDM (4*4) and practically measured channel characteristics using numerical tool. The proposed system support maximum bit rate of 2 Gbps upto the link range of 2500 m with obtained maximum Q factor value of 46 and value of log of BER is -6.9 for RZ-OOK modulation. In our designed system RZ-OOK provide slightly better result than NRZOOK. The proposed system support maximum bit rate of 2 Gbps upto the link range of 2500 m with obtained maximum Q factor value of 42 and value of log of BER value is -3.11 for NRZ-OOK modulation.

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