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A Study on Wireless Transceiver for Visible Light Communication

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Abstract:

In this article, wireless transceiver is studied for visible light communication. VLC is most researched topics due to its secure communication and higher data transfer rate. Visible light utilizes spectrum (430 - 790THz) range which does not overlap with other wireless technologies such as radio spectrum and other. Model efficiency is estimated by calculating bit error rate (BER) from several distance while maintaining speed is consistent and vice versa. In this model on off modulation scheme is used and MATLAB is used as a interface. The visible light communication is used to transfer the data 115.2kbps speed over a 1 meter of distance.

Keywords: Visible light communication, MATLAB, Different modulation techniques

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I. INTRODUCTION

VLC plays the important role in wireless data transfer because of having more superiority such as low power utilization, more security, less cost & high data rate etc [1]. In the visible light communication, alot of study has been done in this field and it still needs to more attention to improvement in VLC [2].VLC is analyzed as the prominent model for transferring the high rate of data. As the highest data rate in the market is still underdeveloped and the demand for high data rate with low cost is rising exponentially. The first concept of using visible light communication was introduced by Bell in 1880, after the invention of LED; visible light communication came in to limelight [3]. There are various types of modulation techniques used to enhance the efficiency of the model in VLC. VLC uses the intensity modulation (IM) and Direct Detection (DD) methods are used to transmit the data. In case of signal carrier modulation, the pulse modulation (PM), pulse position modulation (PPM), pulse width modulation (PWM) and On Off (OOK) modulation techniques are manipulated. Other side multicarrier modulation technique orthogonal frequency division multiplexing is used.VLC provides a frequency bandwidth of about 300THz [4]. This papercontain the designing of wireless transceiver designed with the help of STM32F4 discovery board [5]. Visible light communication use audio which perform both operation of transmitting and receiving. A 100 mbps visible light communication transceiver design using white LEDs [5].Modulation technology, pre-emphasis system and back-end system are used to

enhance data communication rate. Non linear models for visible light communication system it uses different types of equalization i.e. Parallel Hammerstein model (PH-model) and Hammerstein model (H-model).There are three modulation schemes are used for the visible light communication i.e. single carrier modulation, Multi carrier modulation(MCM)and color section modulation [6,7].

II. SINGLE CARRIER MODULATION IN VLC

Single carrier modulation is the most important modulation schemes in visible light communication because of its own advantages and low to moderate data transmission rates [5]. Single carrier modulation modelcomprises the On-Off key, Pulse position Modulation (PPM), Pulse Amplitude Modulation. On off Modulation techniques transmit the data by turning the LED's light on and off accompanying to binary format "1" and "0" [3].For encoding the transmitted data edge transition concept is used where logic '0' is represent as low (off) and logic '1' is represent as high (on) transition. Pulse formats modulation is form by using the serial encoding techniques such as Return to zero (RZ) and Non return to zero (NRZ) [6,7].To converting the digital sequence in to pulse sequence it can be done by improving the amplitude, condition of a pulse and width. Pulse amplitude modulation encodes the message signal in to single pulse carrier [8]. The achievement of these modulation schemes is calculated and correlated on the VLC parameter such as Bandwidth, data transmission rate, error rate.

TABLEI MODULATIONS CHEMES AND RESULT COMPARISON ANALYSIS.

Modulation schemes	**BER**	**SNR(dB)**	**Data Rate**
PWM	High [10]	Low	Lowest
PPM	High[11]	Medium	Low
CSK	Lower [12]	Medium	Medium
OOK	Lowest [13]	High	Medium
MIMO	High[14]	Low	Highest
MPPM	Lower [15]	High	High
VPAPM	Lower[16]	Medium	High

III. MULTI CARRIER MODULATION SYSTEM

In VLC networks as data transmission rate increase single carrier modulation techniques suffers Inter symbol interference (ISI) and non linear distortion [5, 7]. To overcome these problems VLC uses orthogonal frequency division multiplexing (OFDM) by dividing parallel data stream [9].

IV. COLOR DOMAIN BASED MODULATION SYSTEM

Color shift keying is an intensity schemes which transmit a signal through color intensities radiated by Red, Green, and Blue (RGB) light LED's. IEEE802.15.7 standard define the seven wavelengths on the spectrum defining the vertices [3]. Color shift keying (CSK) signal is generated by

these three color bands, the overall intensity of the color output in color shift keying isconsistent. CSK modulates the signal using the intensity of the three colors in the LED source.

V. VLC TRANS MISSION PROCESS

Visible light communication employs LEDs to the transformation of electrical signal into the optical signal. LED &LD have their own advantages and disadvantages [9,10]. LDs have the coherent light that the communication of light wave in single direction and same phase. LEDs have the one major advantage that they travel longer distance also having large bandwidth. LEDs are the most suitable for optical wireless communication transmitter because of having efficient energy, low cost, longer life and improve the color analyzing [7,8].A VLC communication system that consist of two important components, transmitter and receiver.

A. System Design

Wireless transceiver is design for visible light communication system. In this the bit error rate (BER) is measuring for variouslengths by maintaining constant speed and various speed by keeping constant length [2,5]. On Off keying modulation scheme is used here The VLC used to transmit the data 115.2 kbpsspeed at onemeter [11]. The Design of visible light model is usefulfor transmitting and receiving the signal. Block diagram of system design model shown in fig. 1. It mainly comprises of two parts as given below:

- Transmitter section
- Receiver section

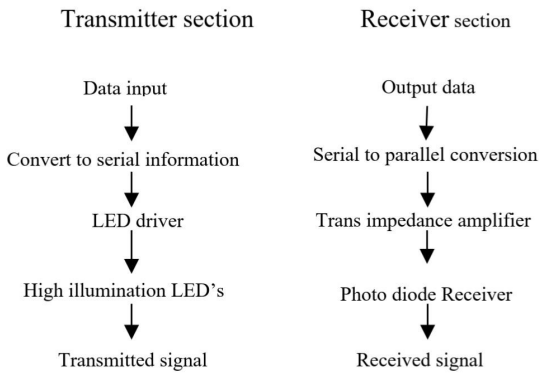

Fig.1 Block diagram of design model [1].

The transmitter includesMATLAB programming and transmits data input. It is usedUSBto UART for conversion of parallel data to serial data. Receiver comprises an array of high speed photodiodes, the photo diode which is used here is BPW34 [1].

B.Design Parameters

In this modelthe input data is taken from external digital source. Input data is used in the form of bytes and it is convert bits with the help of USB and UART convertor which is transformed parallel to serial and it pass to LED driver which is used to amplifies the signal and then passes to high brightness LEDs.

TABLEII

SPECIFICATION OF COMPONENTUSED [1].

Component	**Specification**
photodiode	Wavelength sensitivity: 940 nm Circuit voltage: 39V Rise time/Fall time:45/45ns Reverse dark current:5nA

The transmitted data of LED is received by photo diode which is positioned on receiver side. When any light falls on the photodiode, less amount of current is producedthis is modified into voltage by amplifier and inserted to converter for serial to parallel [2]. This process is also done by USB to UART. The error rate of bit (BER) is measuring for several speed and distances [3, 5].

$BER=N_{Err}/ N_{bits}$ ……(1)

Where

BER= Bit Error Rate

N_{Err}= Number of error bits received

N_{Bits}= Total number of bits transmitted

C..Light Sources

To implement visible light communications the light sources which emit the light must have these vital properties for the proper functioning of the communication system [8,13]. The most commonly used light sources are LEDs, and LDs, these light sources rely upon the excitation condition in semiconductor substances for itsfunctioning. LEDs and LDs have a special property or advantage they are smaller in size and offer low voltage and current. The visibility range of a human eye expands from 400nm to 700nm and In LEDs/LDs research is performed to radiate light across a broader spectrum of wavelengths from visible to infrared [15,16].

D. Light Emitting Diode

The LED is a semiconductordevice which formed by P-N junction. The optical radiation in a LED occurs when we subject it to an electronic excitation by using a forward bias voltage source across the p-n junction. The electrons in the elementenergize through this process and reach an 'excited state' which is a very unstable state. When these electrons reach excited state, they return to the stable state after some time and this leads to the release of energy (photons) [13,14]. In this process, where electrons transfer from valence band to conduction band and again from the conduction to valence band is thereason for the functioning of the LEDs. This process is called radiative recombination [12].

VI. APPLICATIONSOF VLC TECHNOLOGY

VLC have its own advantages as it is more reliable, low impedance cost, high data rate, low power consumption, and more secure. These characteristic of VLC make it desirable for most of application [1, 2].

1. **Public areas:** VLC uses in various devicesi.e. Television, safety purpose etc. It is also use in general places like home, market places and headquarters.
2. **Hospitals:** VLC uses in hospitals where radio frequency is restricted [14].
3. **5G:** VLC makes the 5G generation communication more secure, more efficient, easier and faster.
4. **Airplanes:** Most of the Airlines disallow the use of Wi Fi throughout their flight cause of electromagnetic radiations.VLC provides a substitute communication medium that covers more intelligent airlines.
5. **Underwater awesomeness:** For underwater communication radio frequencies is prohibit so their use VLC technology.

VII. CONCLUSION

Several modulation techniques have been review in this article for visible light communication. A single carrier modulation scheme uses for boost the spectral efficiency. While the Multi carrier

modulation schemes are used for high speed data rate, and large bandwidth.Maximum achieved data transmission rate is obtained 115.2kbps over a length of onemeter. To provide high speed communication orthogonal frequency division multiplexing techniquesand multi output multi input technology is used because of it uses carrier frequencies in Tera Hertz. Visible light communication system will support the internet of things (IOT) and it is applicable for underwater communication, industries, vehicle and etc.

VIII. FUTURE WORK

Visible Light communications is a most interesting and advancing field in the latest technologies. There are several of things to be carry out in the field of VLC systems; the future of this technology uses in implementing it in Home Access Networks. A Lots of Research is going on in the field of MIMO systems for implementing Visible Light Communication in Home Access Networks. Recently there has been new research going on VLC for implementation of Artificial intelligence to detect the presence of the device and operates the lights in the close position. This technology can be used to examine the best lightening device based on the illumination and change the data received from one LED to another LED without dropping of the signal.

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