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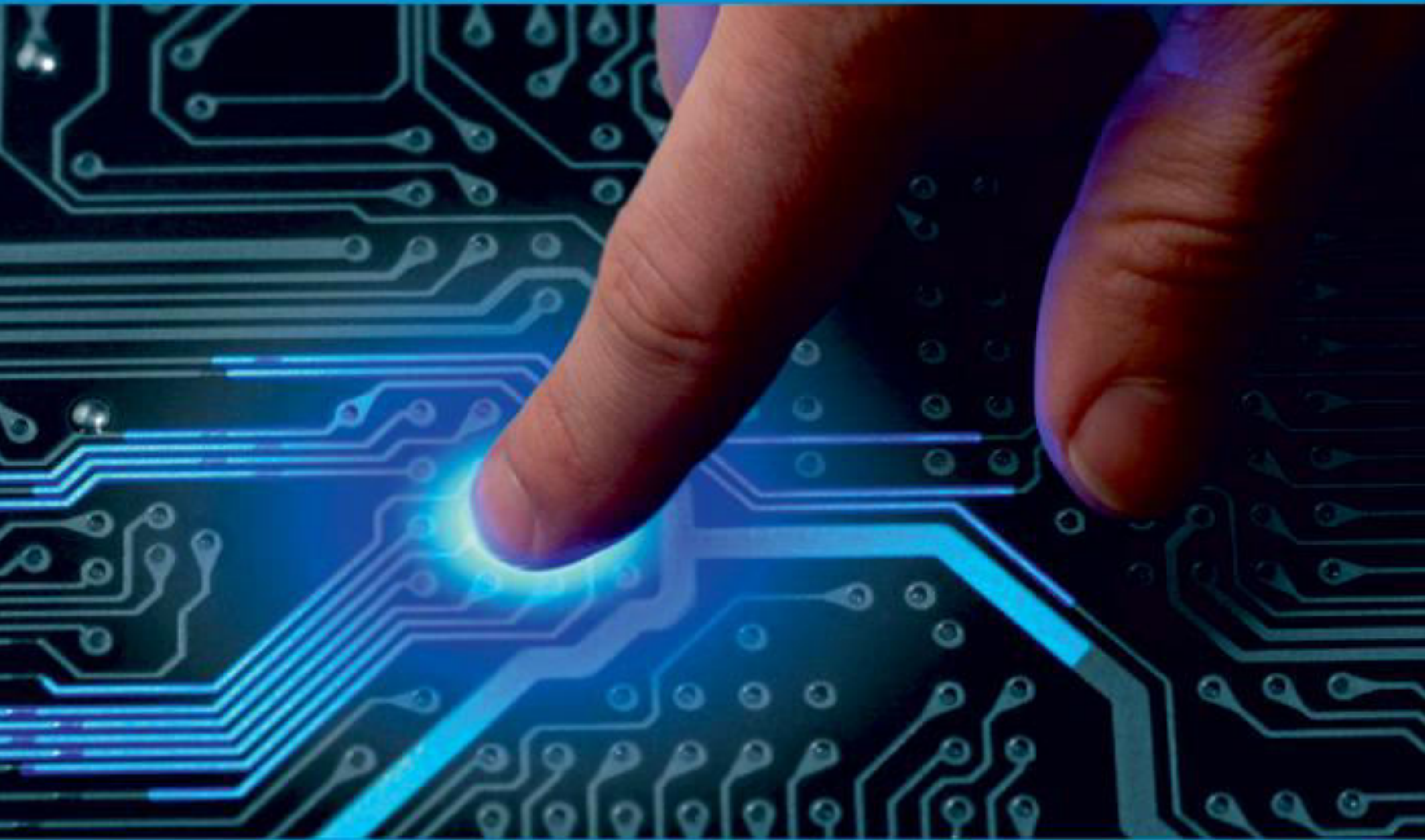

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Review on Visible Light Communication for Wireless Data Transmission

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ABSTRACT: Light Emitting Diodes are set to penetrate many areas of everyday life. An interesting property of these devices in addition to their lightening capabilities , is that they can also be utilised for data transmissions as well. LED's require low power for their operation and have very high switching speeds. This dual purpose application can reduce our dependency on the densely used means of communication the Radio frequency communication.. Visible light communication (VLC) technique using White Light Emitting Diode (LED) is a promising technology for next generation communication for short range , high speed wireless data transmission. LEDs have a number of advantages, one of which is long life expectancy. LEDs' ability to transfer information signals over light makes it a very good communication medium. Now the light we use in our daily life is not only be used for providing light but also for communication. However, like many emerging technologies, VLC has many technical issues that need to be addressed. Using visible light for data transmission entails many advantages and eliminates most drawbacks of transmission via electromagnetic waves outside the visible spectrum .In this paper, inexpensive transmitter and receiver of (VLC) system is designed and implemented experimentally for transmitting data between two computers using Hyper Terminal software.

KEYWORDS: Visible Light Communication (VLC), LED

I. INTRODUCTION

Electromagnetic waves have an extensive range of applications, including cell phone communications, wireless radio broadcast, Wi-Fi, etc. Depending on the wavelength, electromagnetic waves can be roughly divided into radio waves, infrared rays, visible light, ultraviolet rays, etc. Though radio frequency (RF) is not susceptible to low interference, it is capable of wide area coverage [1]. Nevertheless, RF has several disadvantages, such as interference, bandwidth limitations, safety issues, transmission power limitations, and a crowded radio spectrum [2–5]. Therefore, visible light communication (380 to 780 nm) has been developed to solve these challenges as an alternative solution to the problem mentioned above. Wireless optical communication technology is characterized by its emphasis on the realization of high-frequency bandwidth communication capacity, which is significantly greater than the current radio wireless communication frequency. In the past ten years, light fidelity (Li-Fi) technology, which combines illumination and communication, has risen to the forefront of study.

Optical Wireless communication (OWC) has two main advantages: one is that it won't be interfered with by electromagnetic waves. Despite the fact that current flight regulations allow passengers to use electronic devices on planes and vital medical equipment in hospitals, and copper nets are embedded in the walls to prevent mobile phone interference, there are still some chances for interference. On the other hand, wireless optical communication in these sensitive places can avoid interference. The other advantage is power saving; it is more power efficient to turn on and off a LED/LD than to use RF wireless radio frequency to transmit signals. Hand-held devices have limited battery power, so it is more advantageous to use optical wireless communication to transmit signals. Li-Fi technology design is directly combined with the LED bulb of the skylight board to enable hotspot for indoor wireless internet access, and most mobile phones have LED flashes and CMOS camera lenses, which means that they can potentially receive and send information. The beam steering and VLC position combination is a promising solution to directionality between the light source and the receiver [6]. Although the active components of the VLC system will inevitably increase the power consumption, alignment difficulties, cost, and volume of the mobile device, these can be mitigated by utilizing a modulated retro reflector (MRR) in the mobile device; this has been successfully demonstrated recently [7]. In the future, mobile phones may be able to easily exchange information; a schematic of a VLC System is shown in Figure

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1.Crystals 2021, 11, x FOR PEER REVIEW 2 of 29 Optical Wireless communication (OWC) has two main advantages: one is that it won't be interfered with by electromagnetic waves. Despite the fact that current flight egulations allow passengers to use electronic devices on planes and vital medical equipment in hospitals, and copper nets are embedded in the walls to prevent mobile phone interference, there are still some chances for interference. On the other hand, wireless optical communication in these sensitive places can avoid interference. The other advantage is power saving; it is more power efficient to turn on and off a LED/LD than to use RF wireless radio frequency to transmit signals. Hand-held devices have limited battery power, so it is more advantageous to use optical wireless communicationnto transmit signals. Li-Fi technology design is directly combined with the LED bulb of the skylight board to enable hotspot for indoor wireless internet access, and most mobile phones have LED flashes and CMOS camera lenses, which means that they can potentially receive and send information. The beam steering and VLC position combination is a promising solution to directionality between the light source and the receiver [6]. Although the active components of the VLC system will inevitably increase the power consumption, alignment difficulties, cost, and volume of the mobile device, these can be mitigated by utilizing a modulated retroreflector(MRR) in the mobile device; this has been successfully demonstrated recently [7]. In the future, mobile phones may be able to easily exchange information;

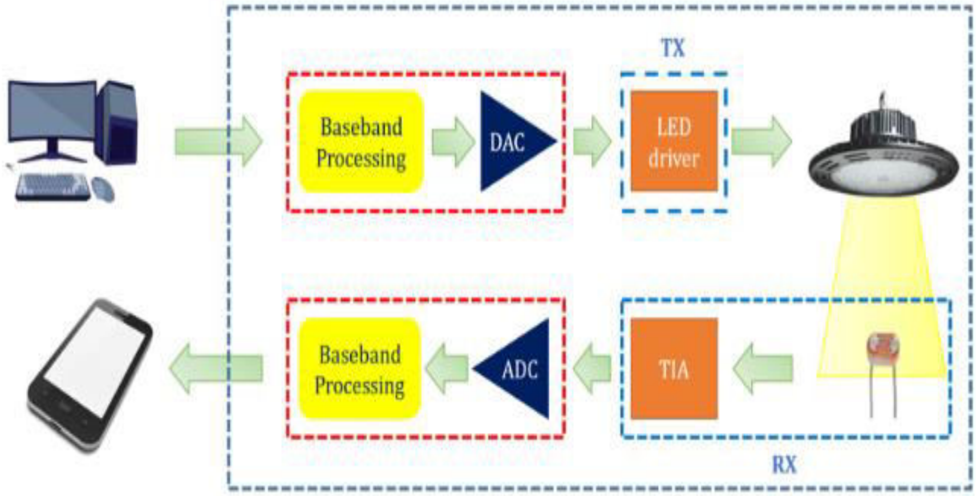

Figure 1. Visible Light Communication System Architecture

Visible light communication is mainly composed of two components: an optical transmitter (Tx) and optical receiver (Rx), as shown in Figure 1. After preprocessing and encoding, a binary bit stream drives the light source (LED/LD), and the electrical signals are converted into optical signals through modulation. Signal distortion generated by other channels is compensated by using pre-processing. The equalization technology can increase the response bandwidth of the LED and increase the transmission data rate. The receiver's post-equalization can compensate for other channel losses, such as phase noise. High-order coding modulation techniques were used to increase the transmission rate and spectrum efficiency.

II. OPEN RESEARCH ISSUES

Flickering is the variations of the intensity of light experienced by humans. In VLC, Lamps must be calibrated to avoid flickering due to adverse human health effects. Flickering is a flicker between frames or a flicker within the frame depending on the size of the image. The flickering inside the frame is attributed to the difference in brightness between the frame bits while the flickering between the frames is due to the difference in brightness between idle and the transmitting time of the packet. Throughout PWM, the pulse train service period is set to monitor brightness; but, in the case of slow data speed or broad idle time, the flicker becomes more noticeable relative to data time. It is therefore an active research field to develop alteration strategies that should minimize flickering.

Different lighting conditions are needed for various activities, such as 30-100 lux necessary for routine tasks and high lighting in offices up to 1000 lux. The opacity algorithms must therefore be designed to meet the necessary illumination in a specific location.

It is important to analyze the quality of different channel coding schemes in VLC. Since the bandwidth of VLC is too small, for better performance, turbo codes with high memory commands should be used. Different decryption algorithms (such as Maximum a Posteriori (MAP), Log-MAP, and Max-Log MAP must be verified

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and validated for element decoders. In order to improve efficiency, linear block codes such as Golay code can also be used in VLC.

It is also a free search space to analyze the performance of specific target diodes in VLC. Specific image diodes, such as optical silicon diodes, Photodiode PIN and photodiode collapse can be used in VLC and tradeoffs between performance, complexity and costs must be rendered. Avalanche optical diodes are very useful, but PINs are low cost more effective storage and good performance in high noise scenarios.

Long-term zeros resulting in flickering, these symbols should therefore be designed to avoid long-term zeros and other symbols and thus stop flickering in VLC.

Noise from ambient light sources limits the efficiency of VLC systems. In Manchester encoding was used without active control and input to minimize background noise. Different techniques to reduce background noise are proposed in [52-53]. Also used to eliminate background noise was Hadamard encoding and Manchester encoding. Coding networks such as rectangular frame codes, Using coiled keys and turbo codes to improve the performance of the VLC device. Turbo codes work better than linear block codes and codes of convolution, But at the cost of the decoder's high overhead and difficulty. Since the maximum bandwidth of VLC is small, using turbo codes in VLC is better. It is therefore an open research field, new codes should be proposed to reduce noise more effectively than previously used.

III. Related Work

Tsonev et al. [1] presented the development of light-fidelity (Li-Fi) systems to be incorporated in cellular networks using orthogonal frequency division multiplexing (OFDM). Potential uplink schemes that could be utilized for these systems were also discussed.

The basic aspects of VLC and power line communication (PLC) systems were surveyed by Ma et al. [2]. The main objective was to find the possibility of integrating PLC and VLC for indoor communication. PLC is a technology that paves way for the existing power cables to be utilized for sending data. MIMO techniques for the integrated system were also discussed. It is possible to directly modulate the LEDs using the data which is being transmitted by the power-line [3], and this makes VLC fit in very well with PLC.

Demers et al. [4], from the networking perspective, presented a paper, which was fixated on FSO. Their work pointed out ways in which an implementation of FSO in cellular networks can be executed in order to elevate the capacity of the network.

In [5], various issues that exist in wireless RF networking technologies were investigated. Studies were done with a perspective on how these issues may be rectified using VLC systems. Furthermore, a discussion on applications, solutions to the existing VLC challenges, and future improvements was presented. Heterogeneous systems, using both VLC and wireless RF, were proposed and implemented by Shao et al. [6]. One system is a hybrid WiFi-VLC network, and the other system is implemented by the parallel aggregation of VLC and WiFi using the Linux operating system bonding technique. For the hybrid network, a VLC channel which is designed only as a unidirectional channel is used as the downlink. To create a complete bidirectional hybrid system, the uplink is established by a WiFi back-channel. The results of this study demonstrated that the hybrid system performs better than the standard WiFi with regards to throughput and the time taken to load web pages for congested areas.

One of the promising techniques to address the key challenges in 5G wireless networks, known as optical NOMA(O-NOMA), was presented by Marshoud et al. [7]. A state of the art integration of O-NOMA into VLC networks was overviewed and analyzed in detail. Current challenges and anticipated opportunities to allow the designs and integration of O-NOMA into VLC systems were also provided.

Zafar et al. [8] focused on the dimming techniques that can be designed and realized for VLC systems. These techniques are anticipated to enable energy-saving and pave way for the provision of illumination control. The study presented a motivation behind the need for dimming control mechanisms, current challenges, driver circuitry, current developments, and the envisioned prospects.

A demonstration of a 3×3 imaging MIMO VLC system was presented by Hsu et al. [9]. The authors extended the bandwidth of the LED transmitter using the preequalization technique. With this technique, the power of components of high frequency such as LEDs can be significantly enhanced while attenuating the low frequency [10]. The authors employed the OFDM and bit-loading algorithm [11] for their modulation scheme. Using the proposed system, it was demonstrated that the 1 bandwidth of the phosphor-coated LED is capable of achieving a data rate of 1 Gbps over a transmission distance of 1 in free-space.

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In [12], the authors outlined and presented a user-centric design of VLC for heterogeneous networks (HetNets). The authors focused on identifying and elaborating a couple of aspects including service provision, system control, and signal coverage quality.

Authors in [13] outlined a framework that presents the viability of using deep-learning (DL) techniques as components for the design of optical communication systems. The authors designed a multicolored VLC system using RGB LED lamps for the realization of multidimensional color modulation as per the outlined color and illumination specifications. The aim of the system is to identify a pair of multicolor modulation transmitter and receiver that yields an efficient symbol recovery performance. An unsupervised DL technique referred to as auto encoder was used to train the recovery process from the receiver to the transmitter. A VLC transmitter-receiver pair and the characterization of the optical channel using the channel layer as well as extra LED intensity control features form part of the recovery process. The transmitter and the receiver are designed together and then optimized. The author's results demonstrated that the designed VLC DL system is better than other proposed techniques with regards to average symbol error probability.

IV. PROPOSED SYSTEM

This chapter will discuss the specifications required for each block of the system architecture, and how it was implemented. These functional blocks are the same for both the transmitter and receiver side, but with different functionalities and implementations. The blocks include power sources, analog circuitry, a microcontroller or digital signal processing (DSP) chip, and a computer.

3.1 Functional Block Diagram

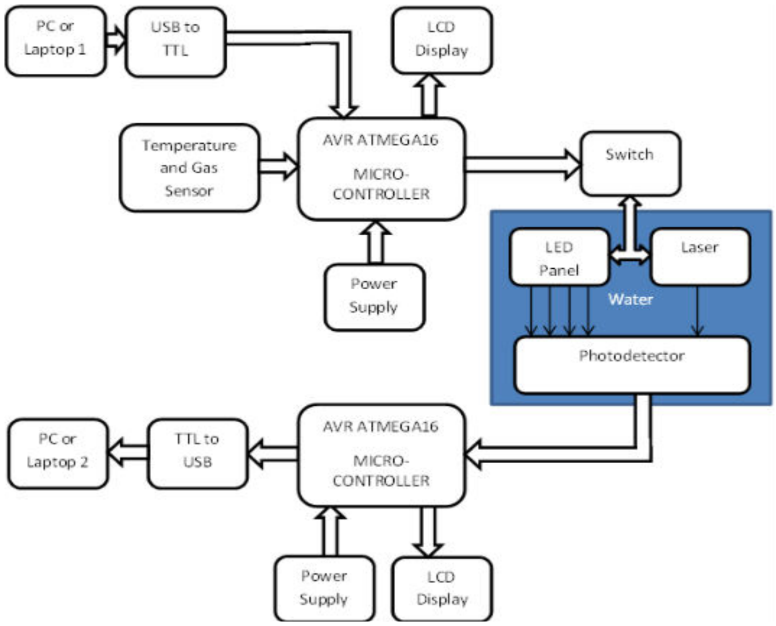

Fig.2. Proposed System

Above Figure shows the overall functional block diagram of our system. The transmitter side consists of a signal source, a microcontroller, and analog circuitry incorporating LEDs, all of which are powered in some fashion. The receiver side is similar, containing analog circuitry incorporating photodiodes, a microcontroller and a device capable of receiving and interpreting the output, all of which are also being powered in some fashion.
The microcontroller is used as the signal source for our design by utilizing a binary system to transmit text. Each voltage maximum corresponds to a single binary 'high' digit and each voltage minimum corresponds to a single 'low' digit. This scheme is used in conjunction with the ASCII binary values, found in Appendix B, to encode a text message which is sent to the receiver side of the design utilizing LED flashes.
A power MOSFET is used to amplify the strength of the signal for increased transmission range. This particular MOSFET includes a built-in gate driver which is necessary for applications involving low-voltage logic such as the microcontroller used in this design. The device works in a way such that the signal is transmitted exactly as intended,

however the logic highs and lows are inverted. To make up for this voltage inversion, the output data signal from the computer will also be inverted to produce the correct signal after the MOSFET block. The operation of this device is explained more in Section 2.2.4.3 MOSFET.

Two different power sources are utilized in the transmitter portion of the circuit. The first is used to power the MCU and is low maintenance since this source is the computer connected to the MCU. Since the MCU needs Code Composer Studio to operate the power from the USB port of the connected computer is used to power the MCU. The second power source is a 5V/2A AC/DC converter connected on one end to a wall outlet and on the other to the drain of the power MOSFET.

The power source for the receiver will be 12V power supply that will supply power to the analog circuitry. The analog circuitry on the transmitter side will be powered by an outlet. The computer will also be powered by an outlet and will either provide a message on the transmission side, or read a message on the receiver side. The DSP chip will be powered by the computer and will decode the message on the transmission side to send a signal through the analog circuit containing the LEDs, or will decode the message from the analog circuit containing the photodiodes. The LEDs will be blinking at a rate corresponding to the message being sent, which the photodiodes will receive at a distance away from this transmission block.

The MCU is connected to a computer using a USB connection cord which outputs 5V DC. This voltage is used to power the MCU while the actual signal is sent to the MCU using CCS. The MCU then outputs either a logic high, 3.3V, or logic low, 0V, to the gate of the next component; the MOSFET. The signal sent from the MCU is applied to the Gate of the MOSFET device which, when high, turns the device on and, when low, turns the device off effectively controlling current flow to the LEDs.

V. CONCLUSION

Visible Light Communication (VLC) present fascinating challenges for using appropriate techniques to construct cheap processing units and high brightness LEDs. Where LEDs lighting technology is being considered as the next generation lighting devices, VLC using LEDs would be promising technology for ubiquitous communication. The technology promises a great mix of importance, from high energy saving using Solid State Lighting technology and high rate data transmission in indoor applications to traffic safety in outdoor environment. The optical wireless communication system is a very good replacement for the

regular communication systems Visible Light Communication is a rapidly growing segment of the field of communication. There are many advantages to using VLC. There are also many challenges. VLC will be able to solve many of the problems people have been facing for many years, mainly environmental and power usage issues. We can be sure that the future for Li-Fi is bright. Li-Fi consortium believes it is possible to achieve more than 10Gbps, theoretically allowing a high definition film to be downloaded in 30 seconds.

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