

Design and implementation of PC to PC data transmission using wireless visible light communication system

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ABSTRACT

In this paper a laser-based visible light communication system for PC to PC data transmission has been designed, simulated, and implemented. This type of communication uses light waves in the visible spectrum (380 nm to 750 nm) to deliver data. Visible light communication is any way of transmitting data using visible light. In order to avoid being detected by human eyes, this kind of communication sends information at a slower rate than human vision. Visible light communication is significantly more reliable and capable of high information transmission rates than existing wireless technologies such as Wi-Fi, Bluetooth, and others that use radio frequency spectrum. Laser-based visible light communication systems are low-cost, low-power, and do not require radio interference studies. A diode laser is frequently used to create the signal carrier. Due to its high efficiency, it can transmit data as well as illuminate. Light waves can't be intercepted because they can't penetrate opaque objects, signifying a very secure connection.

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1. INTRODUCTION

Using the electromagnetic spectrum's visible light part to transmit data is known as visible light communication. Demand for wireless information exchange has grown significantly during recent decades. Until recently, radio frequency spectrum-based wireless communication has been the most popular, but this has led to a rise in congestion. In the future, all types of gadgets will be able to communicate with each other through visible light communication [1]. To begin with, the radio frequency spectrum bandwidth is from 3 kHz to 300 GHz, while the visible light spectrum ranges from 430 THz to 750 THz [2], [3]. Another reason why visible light is preferable to radio frequency is that it can be used in places where RF can be life-threatening, such as space stations, hospitals, and mines [4]. This quality of light ensures data security because it does not broadcast data to outside sources [5]. In 2010, as part of a research effort, a visible light communication system with a data transmission rate of 500 Mbit/s was established. This work purpose is to develop a visible communication system using an Arduino microcontroller. Received data is delivered as a bit stream, which is then converted back into characters by the laser reception sensor upon arrival. Visible light communications (VLC) using a laser diode give a wide bandwidth to cope with the busy radio spectrum [6]. VLC uses air as the transmission medium, visible light between 400 and 800 THz as the signal transmitter, and a laser receiver as the signal receiver [7]. Other compelling features of this technology are unlicensed bandwidth, radiation-free transmission, and high capacity. It's a potential alternative to Radio

frequency (RF) technology for indoor coverage [8]. However, VLC is a backbone that allows unused bandwidth to be used. Due to the fact that light does not pass through the room's walls, visible rays give superior protection than other types. Light-emitting diodes (LEDs) may turn on and off quickly. LEDs can send binary data at fast speeds [9]. Using a powerful laser, it will be feasible to communicate by using the satellite to reflect the signal that the laser beam can emit in a variety of wavelengths from ultraviolet to infrared areas. Because communication channel capacity is related to bandwidth, optical frequencies have far higher capacity than lower frequencies. Laser communication in open air is possible if the weather is normal and the transmitter and receiver are in line of sight [10]. Laser communication has many advantages [11], for communication between two or more devices it is much faster than other methods. Its rates is over 1 GBps so it fully reaches the local area network (LAN) or wireless LAN. Stations transmitting and receiving are smaller and lighter. The frequency range is roughly 400 THz, almost unlimited. Long-distance signal reproduction is distortion-free. Text and sound can be transmitted using one-way laser transmission. VLC, transmitters, and receivers are cheap since it uses visible light. VLC is safe for human health and does not hurt the eye. Numerous works from the early nineteenth century have examined radio waves. Radio communications have become much more effective due to scientific advances. Compared to the radio frequency spectrum of the electromagnetic spectrum, visible light is relatively underexplored as a communication medium [12]-[19].

2. METHOD

The proposed design of VLC system is shown in Figure 1. It consists of three main parts, transmitter, channel, and receiver. In order to evaluate the system performance, our VLC setup has been simulated using optisystem version 15.0.0. The simulation setup of the proposed design is shown in Figure 2, the transmitter consists of external cavity laser source centered at wavelength of 600 nm (red color laser light). The optical binary data is generated by modulating the non-retuned to zero input data using an optical Mach-Zehnder modulator. The receiver consists of photodetector PIN and low-pass filter.

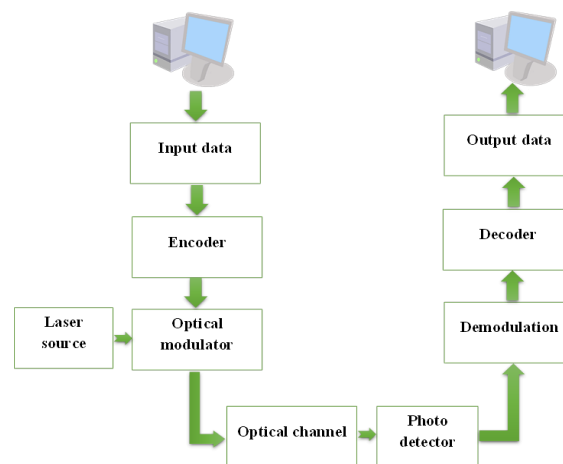


Figure 1. The proposed design of VLC system

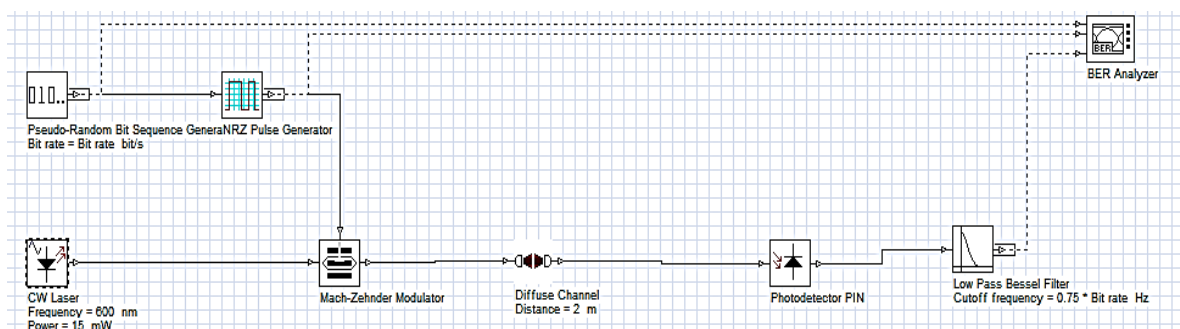


Figure 2. The simulation setup of the proposed design

2.1. Transmitter

On the transmitter side of the VLC system, a personal computer (PC 1) was used to install the Arduino IDE. This computer provides data. A USB connection connects Arduino UNO 1 to PC 1. The Arduino IDE is programmed to transform the ASCII code to binary [20]. The Arduino creates a serial port object with the COM 3 serial port. The baud rate (number of signal or symbol changes per second) is set to 115,200 bits. This object is then attached to the Arduino. It transforms the string to ASCII and then outputs the binary bit stream. The Arduino board has a digital PIN 12 configured as an output. The serial connection's baud rate is then set to 115200 [21], that file contains a 2D array organized so that each 8-bit binary value is indexed as the decimal value of its corresponding character. Because the laser receiver is sensitive to differences in illumination, 1 millisecond is best in the test where there are no errors. The sync bit (always superscript) is the first bit of each character. Syncing the receiver to the transmitter the cool term application is used to choose a text file or write a message. The code is performed once for each character, and the synchronization process is repeated before each character, allowing an endless amount of characters to be sent without issue. Send Char () reads the serial monitor and outputs 0 or 1 as high or low laser states.

2.2. Channel

In Li-Fi, a light beam's major features are affected by atmospheric propagation. The atmosphere is a constantly changing combination of gases, chemicals, and particles (heat). Air cells are constantly moving, creating thermal turbulence in air cells with inhomogeneous refractive index, density, and consistency. The atmosphere strongly influences the polarization refraction, absorption, scattering, and attenuation of the VLC light beam. This causes random oscillations in the light beam between 10 MHz and 200 Hz [22]. Its polarization and coherency fluctuate due to random fluctuations of the air mass along the way, whereas its attenuations fluctuate due to non-consistent power loss across the air mass along the path. In communications, the signal's intensity swings due to random fluctuations in the light beam's Saito-temporal irradiance. In this way, the photo detector is randomly focused. Scintillation is the result of atmospheric turbulence. Laser scintillations prevent gigabit data rates and long-distance optical communications [23], [24]. The scintillation (measured by the scintillation index) is critical for VLC links. The atmosphere channel has several flaws that can cause substantial signal fading or even signal loss. Not just atmospheric turbulence affects the received signal. In circumstances where scattering media such as fog, aerosol, smoke, and dust. are present, a VLC communication channel must be established. Air particle absorption and scattering reduce the transmitted optical signal, while random atmospheric distortions caused by optical disturbance diminish the wavefront quality of the signal-carrying laser beam, causing intensity fading and random signal loss in the receiver [24], [25].

2.3. Receiver side

The receiver captures light and converts it to electricity. Photodiodes are commonly used as receivers in visible light systems [26]. UV and infrared radiation, for example, are captured by photodiodes [27]. They easily saturate in sunlight, for example, and the photodiode fails to receive data due to interference. So other components can capture light. One of them is the smartphone camera, which can receive data from the VLC transmitter. LEDs can also be utilized as receivers because they have photo-sensing properties [28]. Unlike photodiodes, LEDs have advantages in some situations. LED senses lower frequencies than photodiodes, minimizing noise and interference. LEDs' sensitivity is also steady over time. Because LEDs can broadcast and receive, this is a huge advantage. This allows for a system with only one LED per point. This makes VLC programs even easier to use. This work uses a laser sensor receiver. The Arduino IDE is programmed in the loop() where the laser receiver senses the laser high (sync bit), calls start listening() which waits for 3 *delay/2 which means it leaves the sync bit and another half of the delay to start listening in the middle of each bit (reduces the possibility of encountering bit misinterpretation). After that, print Char () transforms the decimal value into a char and prints it. The complete implemented system including the transmitter and the receiver is shown in Figure 3.

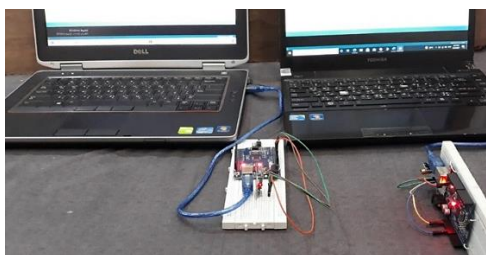


Figure 3. The implementation of the VLC system

3. RESULTS AND DISCUSSION

The system is tested with different input power values starting from 10 mW extended to 35 mW. Figure 4 shows the transmitted bits from the sending side. The transmitted information pulses of 5 volts peak to peak and 1 kbps rate is presented. At the receiver side, the received optical pulses is converted to an electrical form, and then that electrical signal is quantized to two levels based on specified threshold. The quantized electrical signal is presented in Figure 5.

The implemented design is tested using different values of optical input power extended from 10 to 35 mW. Figure 6 shows that the transmitting distance can be increased by increasing the input power. It's clear from the figure, same BER value can be obtained with 9 m distance if the input power is 35 mW while same BER value is obtained after only 5 m distance with 10 mW input power.

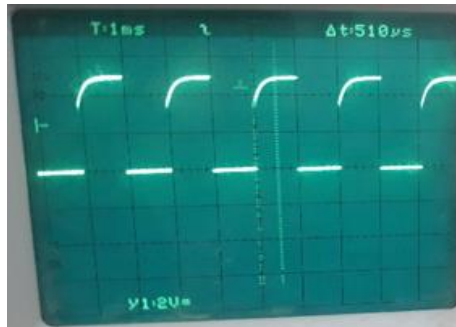


Figure 4. The transmitted signal from the transmitter side

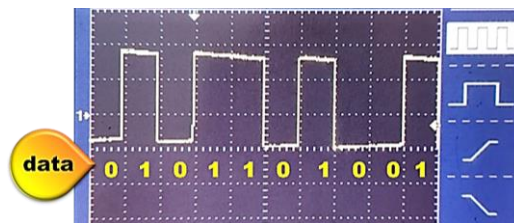


Figure 5. The received binary signal from at the receiver side

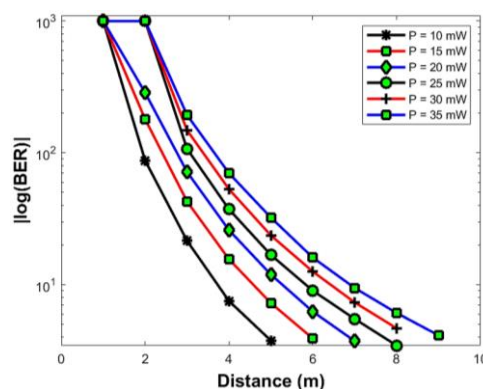


Figure 6. The relation between the distance and BER as a function of the input power

4. CONCLUSION

In this paper, a PC to PC text transmission system using VLC has been designed, simulated, and implemented. This work describes a wireless technique that employs a laser beam to convey text between two PCs. The need of wireless communications increased rapidly due to its flexibility and wide range applications. Employing the Laser technology in wireless communication give us ultra high-speed




communication, high security, and wider capacity. VLC stands out among the newly proposed replacements to existing wireless networking infrastructure. Wireless VLC systems have many applications in specific cases such as indoor networking and underwater communication systems.

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