DESIGN AND IMPLEMENTATION OF VISIBLE LIGHT COMMUNICATION

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Abstract

Currently, the research community has shown very strong interest towards visible light communication. This work explores VLC communication through a prototype implementation. In this work the visible light is being used and IR sensors. The IR sensor have been in practice for receiving of data which is send from the keypad and is further displayed on the receiver side with the LCD. The IR sensor is interfaced at the receiving end. The data is sensed by the receiver side through the blinking of the LED at the transmitter end. The IR sensor receives the data at the same baud rate and displays it on LCD which is interfaced with the Arduino at the receiver end. We were able to transmit small data through VLC. In future, we are planning to transmit live stream and large video files through it.

Key words: Visible light Communication, Device-to-device, Sensors

Introduction

The first device used to communicate without wires in the history of wireless communication was based on electromagnetic waves back to the Photo phone, invented by Alexander Graham Bell in the late 19th century. It was basically used the light produced by the sun to carry the information and was a great achievement at that time. Afterwards wireless communication systems based on lower frequency waves has been introduced and almost all the data sent through the air was carried by waves with frequencies lower than those of the visible light, during the 20^{th} century.

The visible light communication (VLC) is the communication technology which uses the visible light source as a transmitter, the air is used a communication medium, and the appropriate IR sensors or photodiode is used as a signal receiving component.VLC use the white Light Emitting Diodes (LED), which send data by flicking light at the speed which is unable to detect by the human eyes. LEDs' having the ability to transfer information signals in the form of light (light which have the frequency about 400THz to 800THz &the wavelength is between 700nm to 400nm). The main technical development which made is that VLC likely is cheap, high power light-emitting diodes (LED) of high quality, capable for switching at high frequencies. All these need is done by to exchange the already deployed light bulbs with smart and proficient LED bulbs. [3]One interesting application is to communicate between two objects or more than two objects inside the room by using VLC. Light has the dual nature of illumination and as well as transfer the data. An everyday example the infrared (invisible) light in remote controllers, used only to send for a short control signal. According to the directionality between the transmitter, the receiver and the obstacles in the path of light, the link configurations are based on non-directed Line-of -Sight (LOS). The figure 1 below shows the geometry representation.

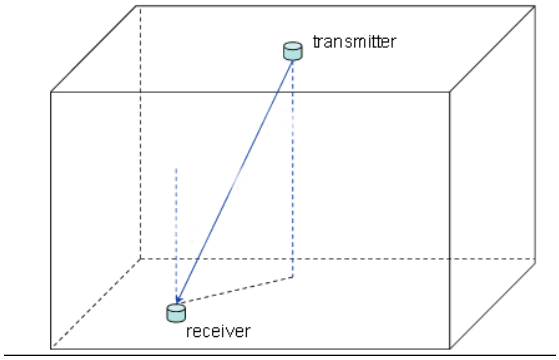

Figure 1: Geometrical Representation of non-directed LOS of VLC

To clear the concept of VLC we first compare it with the infrared communication technology. The main differences between the VLC and infrared communication are listed in Table 1.With the exponentially expanding information request however restricted accessible radio range, options will be important to suit the necessities of the need. This part will delineate the issues of current remote correspondence frameworks and other options to these frameworks, and in addition inspirations and conceivable applications for unmistakable light interchanges.

The Federal Communications Commission (FCC) directs numerous remote applications in the US, including radio, TV, wire, satellite, and link. Every application is given a recurrence band in which it is permitted to work to permit effective utilization of the accessible recurrence range. From Figure 2, forecasts assessed that when even 2013, the US could conceivably be in a range deficiency. Accordingly, a more productive method for using radio recurrence is essential.

Table 1. Comparison of short-range wireless communication technologies (FIR: fast infrared, VFIR: very fast infrared)

	Visible light communication	Infrared communication
Data rate	>100Mb/s possible (LED dependent)	4 Mb/s (FIR), 16 Mb/s (VFIR)
Status	Research and standardization in IEEE	Standardization (IrDA)
Distance	~meters	~3 meters
Regulation	No	No
Security	Good	Good
Carrier wavelength (frequency)	380~780 nm visible light (multiple wavelengths)	850 nm infrared
Services	Communication, illumination	Communication
Noise source	Sun light, Other illumination	Ambient light
Environmental	Daily usage Eye safe (visible)	Eye safe for low power (invisible)
Applications	Indoor & vehicular communication, Optical ID	Remote control, Point-to-point connection

Lights in the unmistakable range are utilized all over the place, giving a few chances to apply obvious light interchanges. There are numerous applications in which information exchange by means of VLC frameworks could be valuable including movement lights, which could use frameworks to streamline activity stream; TV sets, which could supply a client with data on current show postings; and doctor's facilities, which could use the frameworks for more secure exchange of information.

Doctor's facilities have numerous motivations to utilize distant innovation. Use of distant innovation in clinics integrate overhauling data by distantly keeping up patient records, gathering information as a continuous handheld patient screen to identify changes in a patient's condition, or aside watching therapeutic pictures by means of ultrasound.

Smart buildings require smart lighting. VLC provides the Smart lighting, the infrastructure for illumination purposes, controlling and communicating. In the process it greatly reduces the wirings and saves energy usage in the building. It is the fact that the visible light cannot be detected outside of the wall thus had great security advantages. RF does not work underwater while visible light can support the high speed data transmission over short distances underwater. This could be enable divers and underwater vehicles can communication inside the water.

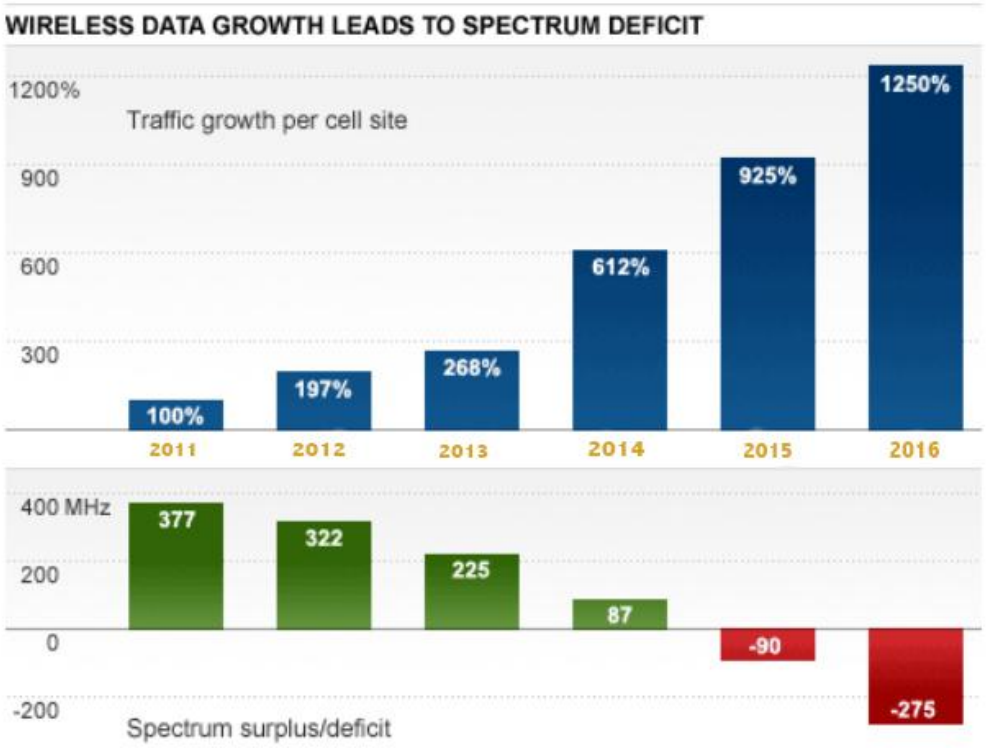

Figure 2 Wireless data growth source

System Model and Experiment Design

The LED based half duplex is used for communication of data. For first prototype the led torch, a small low range led at transmitter side, a photo transistor or IR at receiver side is interfaced. The project consists of two parts, one is the transmitter part and the other is the receiver part. The transmitter part consist of the Arduino UNO connected with system(laptop), the Arduino send

data over serial port and the LED transmit this data in the form of light, also the 4X3 keypad is used instead of system. On the receiver side the IR sensor is used, the data once received is decoded by the MCU and streamed to the LCD where the sent data is displayed. The LCD having a parallel interface, which means that microcontroller, has to influence several interface pins to control the display. The IR which is exchanging On and Off at the rate of 38 KHz. It is dynamic low, implies its yield is stays HIGH when there is no IR, and turns out to be low when it recognizes IR radiation. The IR receiver is considered to be more noise immune than the Light dependent resistor. The system has one limitation that both transmitter and receiver must be in line of sight. The figure shows the block diagram of overall project.

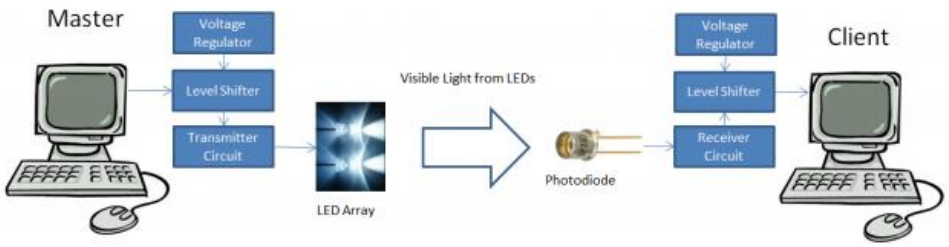

Figure 3: Design of Prototype with USB interface.

Using visible light communication (VLC), the data (Text Message) from transmitter end to the receiver end is transferred. A Line-of-Sight technique, explained to achieve the data at receiver side. The software called "Arduino software" is used at transmitter end to 'type and send' the data and also at the receiver end to 'receive and show' the data on the LCD. The IR sensor which is used on receiving end is having a wavelength of 700 nanometers (frequency 430 THz) to 1 mm (300 GHz).Max232 is used for sending data from computer. The computer is working on TTL logic and the other side is working on digital logic having reference voltage at 0V. In TTL there is negative reference. So that Max 232 works like a TTL to CMOS or CMOS to TTL converter circuit. One transistor is used to invert the output of the sensor. The data is sent on a baud rate of 9600 using visible light. The IR receives the data at the same baud rate and displays it on serial terminal. The transmitter and receiver are placed in front of each other. The system gives error some time and the external light effect the communication.

Result and Discussion

At the completion of the project while, transmitting information from the transmitter side to the receiver side gives up satisfactory results. There were some mistakes whose eradication enhanced the productivity. Diverse information was transmitted through the transmitter and was successfully conceived at the receiver end. The big issues were encountered during the interfacing of Arduino, interfacing of keyboard and LCD. The Arduino UNO was a sharp fix to the issue since it was well known and accessible. In this segment, the other advanced choices brought into practice, for example, Keypad, and LCD. A Programmable Arduino is an incorporated circuit that contains a vast asset of rationale entryways and memory to execute computerized calculations. With an Arduino, it is conceivable to have parallel executions. This would permit the system to test the approaching information without influencing the other process. Arduino could take the information and play out calculation alternately notwithstanding once again into ASCII content. Arduino is additionally more qualified for the signals of light.

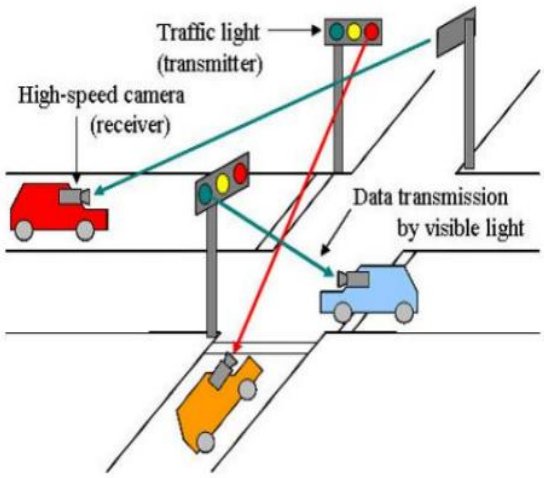

Figure 6 Road-to-Vehicle and Using High Speed Cameras

Conclusions

The initiative has been taken with the undertaking while considering the writing and market overview about information. Since the hardware is not effectively accessible on business sector. The circuit schematic is settled and at the last brought to completely working. The success of this project relied to a great extent upon numerous days of examining and testing. The past learning leads us to more in-depth insight and top of it is said that various upgrades could be made. Building the transmitter for the framework was generally simple. It was a generally clear renovation of the past configurations of the VLC. The plan however introduced more of a challenge in the method, the essential arrangement of these circuit components was general fundamentally the same throughout. The principle difference came in the IR sensor and the MCU's. This project accomplished a transmitting separation of 6cm, with the feasibility to be expanded, at a transmission rate of only 9.6 kbps while working in a surrounding light setting. This VLC model was planned as a continuation of exploration into the field of VLC innovations. Our work will help others to probe more in this field and would help get awesome VLC innovations. This technology is no doubt still in its beginning stages, the usefulness of this technology has high implications for a great amount of good.

Distance – The high demand of the transmitting information could affect the speed of the data and also the distance is dependent as well. So for a short distance it is easy for transmitting the complete data at the receiver side but over a long distance it requires some techniques to transfer the complete either increasing LEDs and IR sensor or the amplifiers used for a long distance transmission.

Cost - The LED-power Li-Fi connection can be used to transmit the information directly with the speed of light. Using this technique office building can stay connected to each other. The use of additional cables is getting rid of. The obstruction would be face by heavy fog, solid objects or the snow would be the only cause of problem.

Traffic Updates Road-to-vehicle and using High speed camera's –The traffic lights update the drivers using the basic information or live-streaming video directly from news broadcasts , keep updating to avoid accidents and traffic headache. For the purpose of communication

medium to communicate Road-to-vehicle, the LEDs are now being used in traffic lights. The figure shows that the LED is used as a transmitter and the camera as a receiver. In the figure shown that the camera is mounted the front end of the car. This camera is used the information receiver from the traffic signal lights.

References

[1] K. Lee, H. Park, and J. Barry, "Indoor channel characteristics for visible light communications," Communications Letters, IEEE, vol. 15, no. 2, pp. 217–219, 2011.

[2] S. Schmid, J. Ziegler, G. Corbellini, T. R. Gross, and S. Mangold, "Using Consumer LED Light Bulbs for Low-cost Visible Light Communication Systems," in Proceedings of the 1st ACM MobiCom Workshop on Visible Light Communication Systems, VLCS '14, pp. 9–14, ACM, 2014

[3] A. Boucouvalas, P. Chatzimisios, Z. Ghassemlooy, M. Uysal, and K. Yiannopoulos, "Standards for Indoor Optical Wireless Communications," Communications Magazine, IEEE, vol. 53, pp. 24–31, March 2015.

[4] H. Elgala, "A Study on the Impact of Nonlinear Characteristics of LEDs on Optical OFDM," PhD Thesis, 2010.

[5] HU Guo-yong†1, CHEN Chang-ying1,2, CHEN Zhenqiang1 "Free-Space Optical communication using visible lights" Optical communication using visible light", Institute of Optoelectronic Engineering, Jinan University, Guangzhou 510632, China.

[6] T. Komine and M. Nakagawa, "Fundamental Analysis for Visible-Light Communication System Using LED Lights", IEEE Transactions on Consumer Electronics, Vol. 50, no. 1, pp. 100-107, February 2004.

[7] T. Komine and M. Nakagawa, "Fundamental Analysis for Visible-Light Communication System Using LED Lights", IEEE Transactions on Consumer Electronics, Vol. 50, no. 1, pp. 100-107, February 2004.

[8] T. Komine and M. Nakagawa, "Integrated System of White LED Visible-Light Communication and Power-Line Communication", Proceedings of IEEE Transactions on Consumer Electronics, Feb. 2003, Vol. 49, pp. 71-79.

[9] H. Haas, "Wireless data from every light bulb ted talk," May 2015.[Online]. Available:http://www.ted.com/talks/harald_haas_wireless_data_from_every_light_bulb#t-205142.

[10] K. Bilstrup, E. Uhlemann, E. Strom, and U. Bilstrup," Enabling Vehicular Visible Light Communication (V2LC) Networks" In EURASIP Journal on Wireless Communication and Networking, Vol. 2009, 2008.

[11] N. Farr, A. Bowen, J. Ware, C. Pontbriand, and M. Tivey, "An integrated, underwater optical/acoustic communications system," in OCEANS 2010 IEEE Sydney, pp. 1–6, IEEE, 2010.