Visible Light Communication

Rajan Sagotra, Reena Aggarwal

Department of electronics engineering
Lovely professional university

Department of electronics engineering
Lovely professional university

Abstract: Visible light communication (VLC) is becoming an alternative choice for next-generation wireless technology by offering low cost, unregulated bandwidth and ubiquitous infrastructures support. This technology is envisioned to be used in a wide range of applications both indoor as well as outdoor. Visible Light Communication (VLC) uses light emitting diodes (LEDs), for the dual role of illumination and data transmission. With this leading edge technology, data including video and audio, internet traffic etc can be transmitted at high speeds using LED light. Using LEDs is helping to drive this technology in the form of Visible Light Communication (VLC).

In this paper, a visible light communications system is proposed that employs wavelength division multiplexing, to transmit multiple data streams from different data sources simultaneously and transmission of audio song and also an image was demonstrated by using LED light. Not limit to this, multiple source signals simultaneously in different frequency bands were transmitted through the LED circuitry, and the signals were recovered successfully. This demonstrates the feasibility studies of our design in signals broadcasting.

Keywords: **VLC (Visible Light Communication), LED (Light Emitting Diode), WDM (Wavelength Division Multiplexing).**

1. INTRODUCTION

Nowadays, a lot of researchers are working on the development of light-emitting diode (LED) lighting system. The LED lighting system can achieve lower power consumption and has a longer life-time compared to the fluorescent lamp system. The Visible Light Communication (VLC) is a fast-growing technology to provide data communication using low-cost and omnipresent LEDs and photodiodes [1]. In the present fast paced life, there is a strong urgency for the improvement in the means of communication. A Wireless network using Visible Light Communication (VLC) is a newly emerging trend that can easily pave the way for a comfortable wire-free future. The usage of light as a source of communication is an innovative and not-yet commercialized technology [2]. In Visible Light Communication (VLC), LEDs used for illumination purpose are simultaneously used for wireless data transmission. It offers numerous advantages such as high data rates, unlicensed large bandwidth and better data security leading to smart spaces [5].

Different solutions have been proposed in literature for VLC system architecture, its performance analysis, improved data transmission rates and brightness control, to name a few. However, VLC has enabled high data-rate (10Mbps), moderate distance (100m), underwater communication [8] as the visible spectrum is subjected to lesser attenuation. Thus, VLC emerges as a suitable alternate where RF fails to deliver due to bandwidth constraints or physical limitations. In this paper, we were discussed about the transmitting of an image and an audio song using LED light bulbs.

The rest of the paper is organized as follows. In Section II, we describe Wavelength Division Multiplexing. Section III, Hardware of the VLC system. Performance Analysis is discussed in Section IV. Application is presented in Section V. Section VI represents the limitation. Section VII concludes the paper.

II. WAVELENGTHDIVISION MULTIPLEXING

Since the technique originally belongs to the field of fiber optics, a general introduction is presented from the perspective of optical fibers followed by the use of wavelength division multiplexing in visible light communications.

A. *A. WDM: A Fiber-Optics Perspective*

In fiber-optic communications, wavelength-division multiplexing (WDM) is a technology which multiplexes multiple optical carrier signals on a single optical fiber by using different wavelengths (colors) of laser light to carry different signals. This allows for a multiplication in capacity, in addition to enabling bidirectional communications over one strand of fiber. This is a form of frequency division multiplexing (FDM) but is commonly called wavelength division multiplexing. The term wavelength-division multiplexing is commonly applied to an optical carrier which is typically described by its wavelength; whereas frequency-division multiplexing typically applies to a radio carrier which is more often described by frequency.

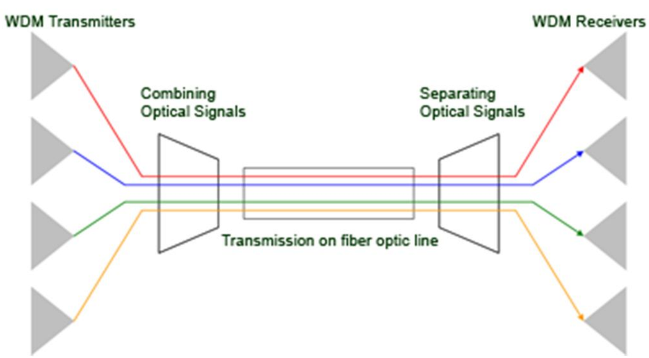

Fig.1. Wavelength Division Multiplexing

III. HARDWARE IMPLEMENTATION

We now present the proposed VLC system which uses WDM to transmit multiple data streams simultaneously. Distinct wavelengths are used for transmitting each data stream by using LED sources of different colors. In the prototype implementation, we transmit an audio stream from one laptop to another laptop.

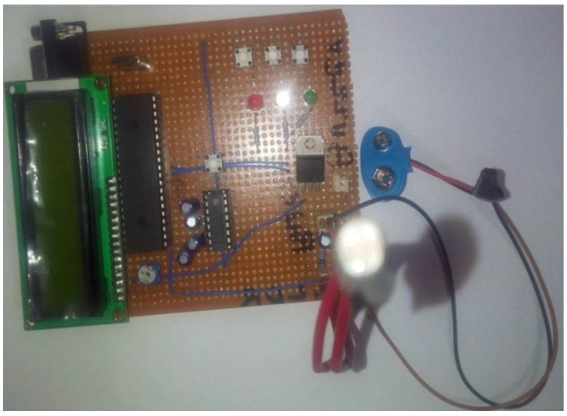

Fig.2. Hardware for VLC System

Firstly, when the hardware is not connected to any battery then it cannot detect any light so that there will no communication. When the hardware is connected to the battery then the hardware displays that there is no light. When we on the Red LED, then the audio song transmit and played by the receiving laptop. If the LED is off, then the audio will be stop. Again if we on the yellow LED, then the audio will be resume and play from where it is stop. It should be noted that single low-cost miniature LEDs were used, rather than the more expensive high power ones, which also accounts for the lower transmission distance achieved (50 cm). Red, yellow and green LEDs were used as visible light data transmitters, while providing illumination at the same time. A computer program was used to send audio data to the serial port. A USB-to-serial converter cable was used to connect the laptop via USB port to an RS232-to- TTL level converter IC (MAX232). Instead of transmitting the audio song, we will also transmit an image from one laptop to another using these LEDs.

IV. PERFORMANCE ANALYSIS

In this paper, we were transmitting an image and an audio song from one laptop to another using visible light communication.

A. Transmitting an audio song:

In the first experiment, we were transmitting the audio song from one laptop to another laptop using LED light (visible light communication) and also played that song. When there is no light then there will no data transmitting and the output result is audio is not playing as shown in figure:

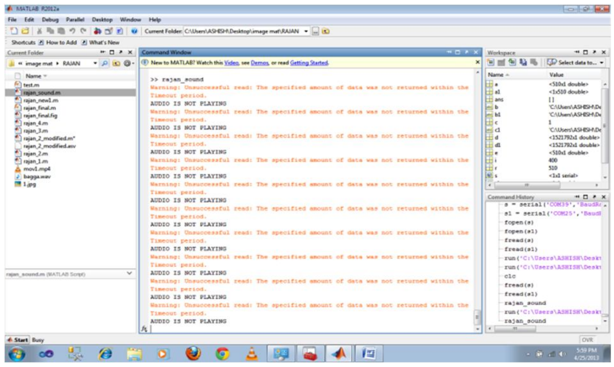

Fig.3. Audio is not playing

When the Red LED is on, then it will send and play the audio songs. It means that where there is light, there will be the data. The output result is audio is transmitted and the audio will playing as shown in figure:

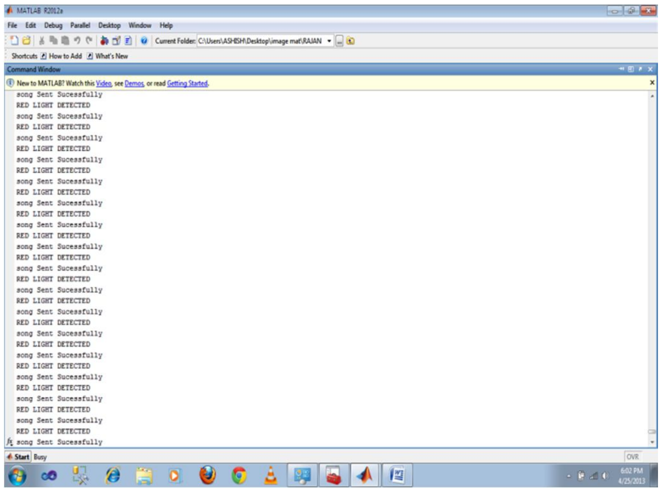

Fig.4. Red LED is detected and audio is transmitted.

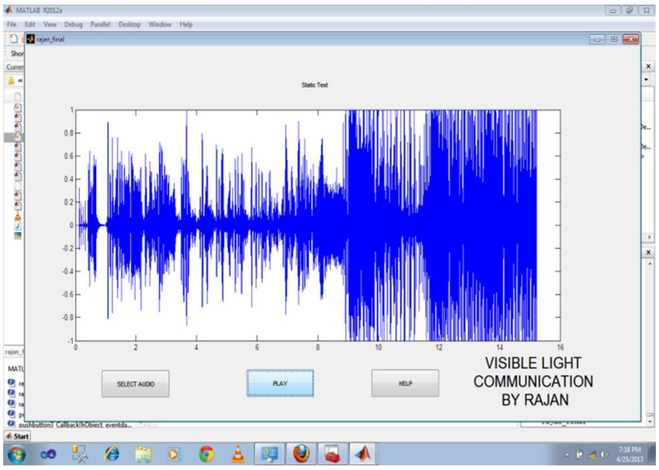

Fig.5. Audio is Playing.

B. *Transmitting of an image:*

In the second experiment, we were transmitting the .JPG image. The format of the image does not affect the transmission in any way hence, an image of any of the regular formats- .jpg, jpeg, .bmp etc. can be selected. We are using the following .jpg image having dimensions 92*112.

Fig.6. Image to be transmitted.

When there is no light, then the image is not transmitted from one laptop to another. The output is as follows:

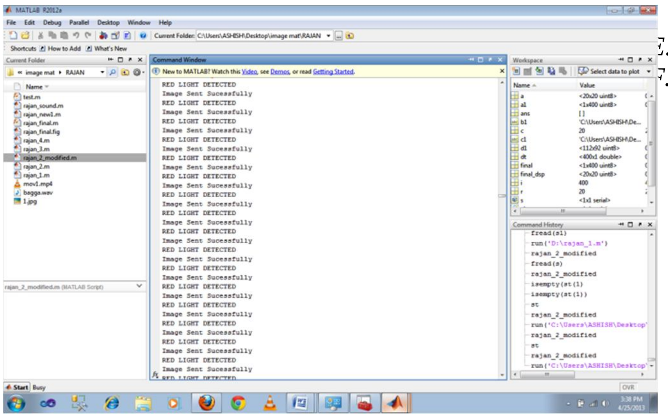

Fig.7. Red LED is detected

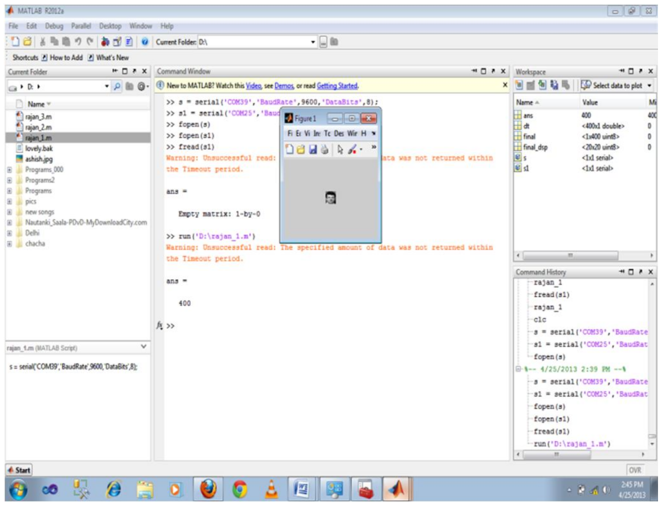

Fig.8. Image transmitted successfully.

V. APPLICATIONS

The applications for this technology are limitless owing to the fact that light is probably the safest source of energy there is:

A. Smart Lighting

Smart buildings require smart lighting. Smart lighting with VLC provides the infrastructure for illumination, control and communications and will greatly reduce wiring and energy consumption within a building.

B. Mobile Connectivity

By pointing a visible light at another device you can create a very high speed data link with inherent security. This overcomes the problems of having to pair or connect and provides a much higher data rate than Bluetooth or WiFi.

C. Hazardous Environments

Communicating in areas where there is risk of explosions can be a problem (e.g. in mines, petro-chemical plants, oil rigs etc.). VLC is inherently safe and provides both safe illumination and communications.

D. Vehicle & Transportation

Many cars already LED lamps. Traffic signage, traffic lights, and street lamps are adopting the LED technology so there are massive applications opportunities here [4].

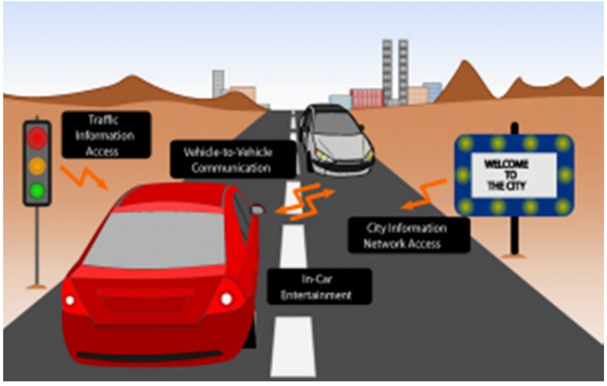

Fig.9. VLC for Automotive Applications

G.

H. E. Defence & Security

The ability to send data quickly and in a secure way is the key to many applications. The fact that the visible light cannot be detected on the other side of a wall had great security advantages.

I.

J. F. Hospitals & Healthcare

There are advantages for using VLC in hospitals and in healthcare. Mobile phones and WiFi's are undesirable in certain parts of hospitals, especially around MRI scanners and in operating theatres.

K.

G. Wifi Spectrum Relief

WiFi have got faster over but cannot keep up with demand for wireless data. VLC can provide data rates greatly in excess of current WiFi and this can be done at low cost since the RF components and antenna system have been eliminated.

H. Aviation

Radio is undesirable in passenger compartments of aircraft. LEDs are already used for illumination and can also be used instead of wires to provide media services to passengers. This reduces the aircraft construction costs and its weight.

I. Underwater Communications

RF does not work underwater but visible light can support high speed data transmission over short distances in this environment. This could enable divers and underwater vehicles to talk to each other [8].

J. Location Based Services

Each visible light information source can be uniquely identified, so the location of any VLC device can be identified quickly and accurately.

VI. LIMITATIONS

The biggest limitation at present is the limited coverage range. Even with high power LED's practically required communication distances are not achievable. [14] presents extensive prototypes for visible light communication but still does not achieve sufficient range. Another limitation is that to implement applications, the existing infrastructure will need to be revamped. In above mentioned street light application, it is assumed that existing lighting will be replaced with high power LED sources. Although, it will prove to be beneficial in more than one way, passing such resolutions would take significant time and cost. The third limitation is to break into full-duplex mode. It would be a formidable task for a single module to transmit a modulating signal and at the same time receive and detect another modulating signal. Initial ideas include using LEDs of different wavelengths, shielding and optical isolation of transmission and receiver modules and using adaptive digital filters. Though plausible, such methods require extensive testing and research and there is barely any development on this front. Full-duplex has only been achieved by using visible light for front-end communication and using IR for back end or by morphing visible light communication with power lines.

VII. CONCLUSION AND FUTURE SCOPE

The method of transmitting an image and an audio song using visible light and successful reproduction has been shown, thereby, presenting a feasible method of using visible light for safe and cheap data transfer. The various steps to achieve transmission and faithful reproduction of the image and also transmission of an audio song have been described. Though, this technology is still in its infancy, with further studies and development its far-reaching applications will only get better. The VLC technology is all about using LED light bulbs meant for illumination to also send data simultaneously. It is best suited as an additional option for data transfer where radio transmission networks are not desired or not possible. In future, we can transmit an image, audio and even an high definition video using an LED light bulbs.

REFERENCES:

[1] J. Kahn and J. Barry, "Wireless infrared communications," Proceedings of the IEEE, vol. 85, no. 2, pp. 265–298, 1997.

[2] Felix Schill1, Uwe R. Zimmer1, Jochen Trumpf, "Visible Spectrum Optical Communication and Distance Sensing for Underwater Applications", proceedings of ACRA 2004.

[3] M. Nakagawa, "Visible light communications," in Conference on Lasers and Electro- Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies, 2007.

[4] 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.

[5] H. Le Minh, D. O'Brien, G. Faulkner, L. Zeng, K. Lee, D. Jung, and Y. Oh, "High-speed visible light communications using multipleresonant equalization," Photonics Technology Letters, IEEE, vol. 20, no. 14, pp. 1243–1245, 2008.

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

[8] 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.

[9] Akassh A. Mishra and Neelesh S. Salian,"Internet using Visible Light Communication" IACSIT International Journal of Engineering and Technology, Vol. 3, No. 5, October 2011.

[10] 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.