SURVEY PAPER ON VISIBLE LIGHT COMMUNICATION

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Abstract— Visible Light Communication system uses visible light sources for wireless data transmission. VLC (Visible Light Communication) is also known as Li-Fi (Light-Fidelity). Li-Fi technology, put forth by the German physicist Harald Haas. VLC transmits data through illumination i.e. by sending data through an LED light bulb that differ in intensity faster than the human eye can follow. VLC based communication is emerging as a most propitious solution for in air, underwater wireless communication systems. As an alternative system against conventional acoustic systems, VLC can achieve high data rate. With this leading edge technology, data including text, video, audio, internet traffic, etc, can be transmitted at high speeds using LED light. One can off-load some traffic from existing RF channels, and extend cellular and Wi-Fi capacities using VLC as demand for RF frequency is increasing day by day. But VLC can't totally replace RF frequency.

Index Terms—VLC, LI-FI, LED, WI-FI, RF

I. INTRODUCTION

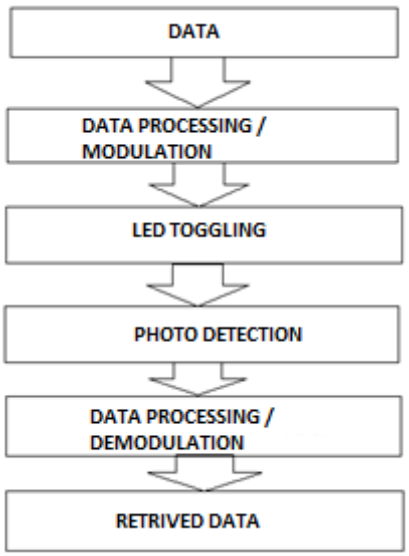
In 1880s in Washington, D.C the Scottish-born scientist Alexander Graham Bell invented the photo phone, which transmitted speech on modulated sun light over some distance. This pre-dates the transmission of speech by radio. The visible light communication (VLC) can relate to the communication technology which uses the visible light source as a signal transmitter, air and/or water as the transmission medium, and the felicitous photo-diode as a signal receiving component [1]. In VLC transmission of data is done via illumination or visible light i.e. data can be send through an LED light bulb or florescent light bulb that differs in intensity so fast that the human eye can't follow. VLC is the fast, cheap, easy to use, license free wireless communication system, which is the optical version of Wi-Fi and can be used indoor and outdoor. VLC uses visible light instead of Gigahertz radio waves for data transfer. The idea of VLC was introduced by a German physicist, Harald Hass, in 2011 in his TED Global talk on Visible Light Communication. He also referred VLC as data through illumination. According to Hass, the light, which he referred to as D Light, can be used to produce data rates higher than 10mbps which is much faster than our average broadband connection [2]. VLC uses visible light with wavelength 375 nm - 780 nm or 3.75×10^{-7} to 7.80×10^{-7} m, and frequency 400THz - 800THz as visible carrier for data transmission and illumination. VLC uses fast pulses of light to transmit information wirelessly. As said by Harald Hass, 100million times/second LED can turn ON and OFF to transmit data [3].

II. METHODOLOGY

Methodology section explains the flow of the VLC system.

The data in the form of text, Image, or video is given as an input from the sender PC to the data processing unit. Data processing is done in the transmitter section microcontroller connected to PC and/or mobile device through USB to TTL serial port. Depending upon the output of microcontroller the led's connected to one of its port gets toggled. At the receiver side photo-diode detects the data, sends it to the receiver microcontroller. Receiver section microcontroller processes data and sends it to the receiver PC via USB to TTL serial port. And one can see the data at the receiver PC and/or mobile device.

Fig1. Flow Chart of VLC System



III. PRINCIPLE OF VLC TECHNOLOGY

VLC is a short range optical wireless communication technique which uses LEDs for both wireless communication and illumination concurrently. LEDs have many advantages over conventional lighting devices like Mean Time before Failure, high lighting efficiency, specific spectrum, environmental friendliness so instead of using florescent light source LEDs can be used. Data transmission in VLC is done by changing the light intensity of LEDs. The modulation speed of LED is very high so it is used for easy data transmission. Right choice of modulation scheme, selection of VLC compatible components, use of equalizers and amplifiers at transmitter and receiver can help to improve the performance of LED [4]. The important section of the VLC technology is the high power Led lights and photodiode. LED can be turned on & off quickly because the response time of the LED is not more than 1microsecond which is undetected by the human eye this will appear to be continues line of light. This change from high state to low state in high frequencies enables the data transition. A photo detector is used to receive the transmitted data from the light source and generates the original data. This method of continuously receiving the pulses of light and decoding into the stream of data is referred as visible light communication [7].

a. DEVICES USED IN VISIBLE LIGHT COMMUNICATION

The devices used in the VLC are Led lights or florescent light source and the photo detector. LED is more favorable than the existing incandescent in terms of high endurance to humidity, less power consumption, minimal heat generation lighting, lower operating voltage, longer lifetime, smaller size, and cooler operation. LED lights have two basic properties, a) luminous intensity and b) transmitted optical power. The unit indicating the energy flux per a solid angle, related to luminance at an illuminated surface is known as Luminous intensity. The luminous intensity is used to show the brightness of an LED. As optical communication point of view the transmitted optical power shows the total energy radiated from an LED [5].

Fig1. LED

Fig2. Photodiode

For the data reception receiver should be present at the receiver side of the design. For this purpose photodiode is used. Photodiode react to the light emitted from the LEDs and allow for current to flow to the rest of the receiver circuit. When there is no light emitted from the LEDs the photodiode do not allow current to flow through to the microcontroller unit on the receiver. Photodiodes can be used to detect the presence or absence of minute quantities of light and it can measure from intensities between 1pW/cm2 to 100mW/cm2 [9]. Photo detectors will respond swiftly to all received photons sent by the transmitter without introducing any extra noise. Photodiodes are small, robust, power efficient and cheap. In this application, switching speed is the top priority for a photon detector, followed by light sensitivity.

There are different types of opto-electrical devices that can be used as photo detectors like photo multiplier tubes, photo transistors, and photodiodes. Photodiodes can work fast with moderate power consumption and especially, photodiodes which is highly responsive for the wavelength of 420nm/4.20 × 10^{-7} m range is more suitable for wireless UWOC (Under Water Visible light Communication) [11].

b. CONSTRUCTION AND WORKING OF VLC SYSTEM

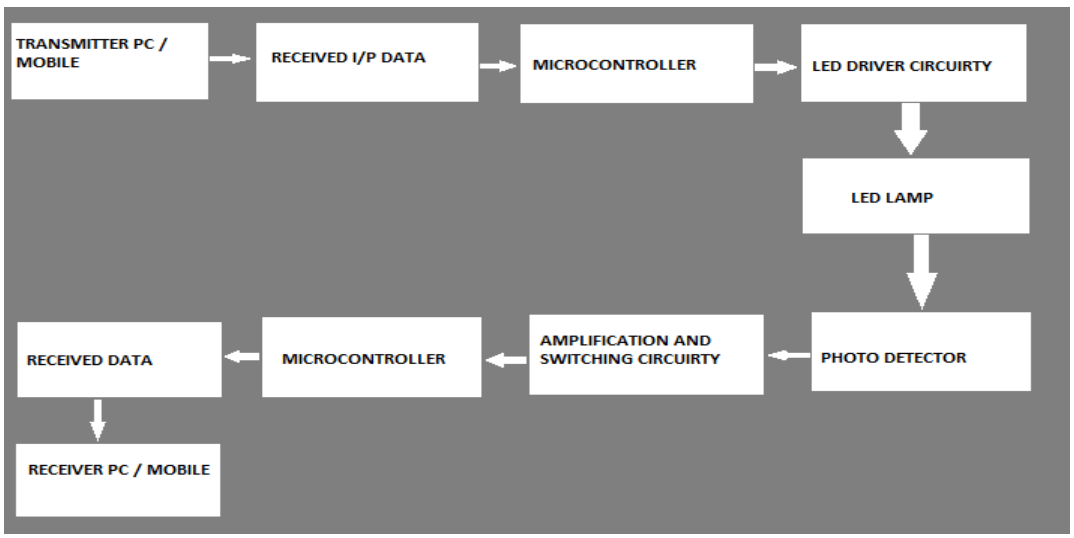


Fig3. Block diagram of VLC System.

From the transmitter side PC and/or mobile device data is sent to the microcontroller. This microcontroller sends data in the form of 0's and 1's to LED driver circuitry. LED driver circuitry applies binary coded data to an LED light bulb which emits a constant stream of photons which is observed as visible light. When the current becomes high for binary 1 and low for binary 0 the output intensity of the light dims more and less. Because LED bulbs are semi-conductor devices, the optical output, get modulated at incredibly high speeds which is detected by a photo-detector device, the detected data get converted back into a data stream get amplified and transmitted to the receiver side microcontroller. The controller sends data to the receiver PC and/or mobile device.

The intensity modulation is indistinguishable to the human eye, so communication becomes as seamless as RF. Using VLC technique, high speed data can be transmitted from an LED light bulb [7].

IV. VLC MODULATION TECHNIQUES

Different methods can be used to modulate the data over the visible light spectrum, some methods are;[2] [6]

On-off keying (OOK): One of the oldest modulation techniques, with less complexity and good performance is On-off keying (OOK). And it is the simplest form of amplitude-shift keying (ASK) modulation. System hardware can easily implement and integrate OOK modulation technique. Therefore, it is applicable to any digital encoding scheme. OOK represents digital data as the presence and absence of carrier wave that means the data is conveyed by turning the LED on and off. A digital '1' represents 'on' state and a digital '0' represents 'off' state of light. This method is really simple to generate and decode. OOK is very sensitive to noise; hence, the most challenging problem is the proper design and selection of the components especially of receiver side. So, OOK method is not effective for illumination control and data throughput.

Pulse width modulation (PWM): This method encodes a message or information into pulsing signal. More than one bit of data can be conveyed within each pulse, but the pulse may be longer than for OOK, so there is no great advantage with PWM. It is also possible to transmit data in an analogue form using PWM which is relatively simple to implement.

Pulse position modulation (PPM): For PPM the data is encoded using the position of the pulse within a frame. In PPM, data transmitted in short pulses has the same width and amplitude. The PPM changes the delay between pulses. Each delay between pulses is represented by a zero or a one. Zero represents small delay and one represents long delay. The duration of delay varies according to the system's requirements. PPM is very sensitive to external interferences. Although interference is usually impossible to detect, it can cause complete data corruption. Therefore, the PPM is the mainly used in optical communications systems where no multipath interference exists.

Color shift keying (CSK): CSK can be used if the illumination system uses RGB type LEDs. By combining the different colors of light, the output data gets carried by the color itself and thus intensity of the output can be constant. The disadvantage of this system is the complexity of both the transmitter and receiver.

Orthogonal Frequency Division Multiplex (OFDM): OFDM is a method of encoding digital data on multiple carrier frequencies. This modulation scheme has been widely used for digital TV audio broadcasting, DSL Internet access, wireless networks, power line networks, and 4G mobile communications. It can be modified for use in optical communications. There are number of advantages like good spectral efficiency but OFDM is complex to implement.

V. ADVANTAGES AND DISADVANTAGES OF VLC

VLC technology is based on LEDs or other florescent light source with different electromagnetic spectrum for data transfer. That is, the light can be the invisible, ultraviolet or the visible part of the spectrum. The communication speed of VLC is more than sufficient for downloading data in very less time. Also, VLC overcomes the limitations that have been put on the user by the Wi-Fi.

WI-FI gets interfered if we use more routers at the same place but VLC does not get interfere, this is the big advantage of VLC over Wi-Fi [10].

Advantages of VLC

a) Capacity: LED or other florescent light has 10000 times wider bandwidth than RF waves. Also, light sources are already installed at offices, home and public places etc. So, VLC equipments are easily available with better data transmission capacity

b) Efficiency: LEDs used for data transmission are of low cost with longer lifetime, high efficiency and less energy consumption so Data transmission using VLC is very efficient.

c) Availability: Billions of light sources are present in world so just by replacing all the sources with LEDs data can be transmit easily using VLC.

d) Security: Light waves do not penetrate through walls and other opaque materials. So, the data get prevented from misuse.

With the advent of VLC, now it is not mandatory to be in a region that is Wi-Fi enabled to have access to the internet. One can simply stand under any form of light and surf the internet as the connection is made if light is present.

Disadvantages of VLC

a) The artificial light cannot penetrate into walls and other opaque materials. So a VLC enabled end device will never be as fast and handy like Wi-Fi enabled device in the open air.

b) It only works in direct line of sight.

Still, VLC could emerge as a boon to the rapidly depleting bandwidth of radio waves. And it will certainly be the first choice for accessing internet in a confined room at cheaper cost.

VI. APPLICATIONS

There are many applications for VLC. These include:

- **Smart Lighting**: Any private building, public places or street require lighting lamps. These lamps can be used to provide VLC hotspots and the same infrastructure can be used to monitor and control lighting and data. This will reduce wiring and energy consumption and cost of the system.
- **Mobile Connectivity**: At Short range links Laptops, smart phones, tablets and other mobile devices can interconnect directly using VLC which gives very high data rates and security.
- **Hazardous Environments**: VLC provides a safe communication and illumination in environments such as mines, oil rings and petrochemical plants where risk of explosions due to RF frequency can be a problem.

- **Hospital & Healthcare**: VLC can be used in healthcare as it does not emit electromagnetic interference and so doest interfere with medical instruments, and MRI scanners. Mobile phones and WIFI are not allowed in hospitals so for safe and healthier data transmission VLC can be used.
- **RF Spectrum Relief**: Excess capacity demands of cellular networks can be fulfilled with the help of VLC networks where light is available. And this can be done in low cost as VLC does not require any antenna and costly components like RF.
- **Aviation**: In aircraft LED lights are used for illumination which can be used as VLC structure for wireless data transmission.
- **Underwater Communications**: RF signal get absorb in water. But VLC can provide high speed data transmission over short-range communications. Therefore VLC can help under water vehicles and drivers to communicate with each other.
- **Vehicles & Transportation**: LED headlights and tail-lights of vehicle, Street lamps, signage and traffic signals can be used for vehicle-to-vehicle and vehicle-to-roadside communications. This can be applied for road traffic safety and management and thus to reduce road accidents.
- **RF Avoidance**: People who are hypersensitive to radio frequencies can use VLC for healthier and secure data transmission
- **Defense & Security**: Visible light cannot be detected by other side of opaque material or wall gives great security for data transmission.VLC can send data very quickly.
- **Location Based Services (LBS)**: Location of VLC device can be identified quickly and accurately to receive appropriate, relevant information in a timely manner.
- **Toys**: Many toys integrate LED lights which can be used to enable low-cost communication between interactive toys [7].

VII. CONCLUSION

A survey on visible light communication has been presented.VLC can be used everywhere visible light is present specially LED light.VLC can't penetrate through body so can be used in medical applications.VLC means a greener, safer, and healthier future of wireless data transmission and also it will give license free, cheap in cost, and near unlimited wireless data in future. For data transmission we can use LEDs with different color or Laser and for reception Photodiodes are used**.** Apart from land and air, sea has also become very important from defense strategic point of view and is required to get included with network centric communication. In future VLC may play a very important role in network centric communication. Free space VLC communications provide wide bandwidth and high security capabilities to unmanned aircraft systems in order to successfully carry out intelligence, surveillance, target acquisition etc.

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REFERENCES

[1] Chung Ghiu Lee (2011).Visible Light Communication, Advanced Trends in Wireless Communications, Dr. Mutamed Khatib (Ed), ISBN: 978-953-307-183-1.

[2] M. Saadi, L.Wattisuttikulkij, Y. Zhao, P. Sangwongngam "Visible Light Communication: Opportunities, Challenges and Channel Models" International Journal of Electronics and Information Vol. 2, No. 1, 2013.

[3] M. V. Bhalerao, S. S. Sonavane, V. Kumar "A Survey Of Wireless Communication Using Visible Light" International Journal of Advances in Engineering & Technology, Jan. 2013. Vol. 5, Issue 2, pp. 188-197.

[4] Sridhar Rajagopal, Samsung Electronics Richard D. Roberts, IntelSang-Kyu Lim, ETRI "IEEE 802.15.7Visible Light Communication: Modulation Schemes and Dimming Support" Communications Magazine, IEEE, (Vol: 50, Issue: 3) March 2012

[5] Toshihiko Komine, and Masao Nakagawa " Fundamental Analysis for Visible-Light Communication System using LED Lights" IEEE Transactions on Consumer Electronics, Vol. 50, No. 1, FEBRUARY 2004

[6] Jacqueline J.George1, Mohammed Hayder Mustafa, Nada Mahjoub Osman, Nuha Hashim Ahmed , Da'ad Mohammed Hamed "A Survey on Visible Light Communication" International Journal Of Engineering And Computer Science Volume 3 Issue 2, February 2014

[7] C.Periasamy, K.Vimal, D.Surender "LED Lamp Based Visible Light Communication in Underwater Vehicles**"** International Journal of Engineering Trends and Technology (IJETT) – Volume 13 Number 3 – Jul 2014

[8] www.purelifi.com

[9] www.osioptoelectronics .com

[10] R.Karthika, S.Balakrishnan **"**Wireless Communication using Li-Fi Technology" SSRG International Journal of Electronics and Communication Engineering (SSRG-IJECE) volume 2 Issue 3 March 2015 ISSN: 2348 – 8387

[11] C.T.Poomagal, M.Athappan "Wireless Optical Communication for Underwater Applications" International Journal of Advance Research in Electronics and Communication Engineering (IJARECE) Volume 3, Issue 3, March 2014