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Methodology to Achieve Enhanced Data Transmission Rate using Li-Fi in VLC Technology

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Abstract- ***Li-Fi (Light Fidelity or optical Wi-Fi) is the transmission of data using light waves by varying the light intensity faster than human eye can follow using Visible Light Communication (VLC) technology in free space. This is just like as "Data Through Illumination". VLC uses rapid pulses of light to transmit information wirelessly. VLC using LEDs is emerging as a key technology for a ubiquitous communication system, because LED has the advantages of fast switching, long life expectancy, being less expensive and being visible light that is safe for the human body. LEDs are different from the other kinds of lamps because they are semiconductors. This characteristic gives them the capability to switch-on and off within few nanoseconds or billionth of a second. Converted in terms of data rates, this corresponds to 1 Gbits/s or more. In order to compare, at best Wi-Fi can reach 100 Mbits/s data rates and so at least 10 times or more lower. Here we shows some new conceptual methods by which we can transmit data in parallel using VLC technology. If this application is put into use, we can use every bulb like a Wi-Fi hot spot to transmit the data with ultra-high speed such as more than 10 Gbits/s.***

Keywords- ***Li-Fi, Visible Light Communication (VLC), Wi-Fi, LED, Radio & Light Spectrum.***

I. Introduction

The LED has been studied as a future energy-saving light source. Significant developments in aluminum gallium indium phosphide (AlGaInP) technology have seen red and amber LEDs penetrate the automotive and traffic signal markets.

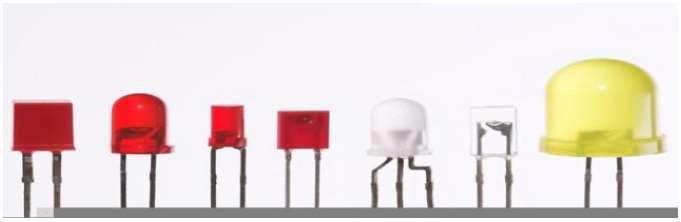

Fig.1: LEDs

In simple terms, Li-Fi can be thought of as a light-based Wi-Fi. That is, it uses light instead of radio waves to transmit information. The VLC concept directly sprouts from the use of optical spectrum in indoor wireless communication systems, initially introduced in 1978 by Gfeller. Visible light communication (VLC) is a data communications medium using visible light between 400 THz (780 nm) and 800 THz (375 nm). Visible light is not injurious to vision. Light is in fact very much part of our lives for millions and millions of years and does not have any major ill effect. As radio-based wireless becomes ubiquitous, more and more devices transmitting more and more data are able to connect to the internet, either through the mobile-phone network or through Wi-Fi. But there is only a limited amount of radio spectrum available. Moreover there is 10,000 times more space available in this spectrum and just counting on the bulbs in use, it also multiplies to 10,000 times more availability as an infrastructure, globally.

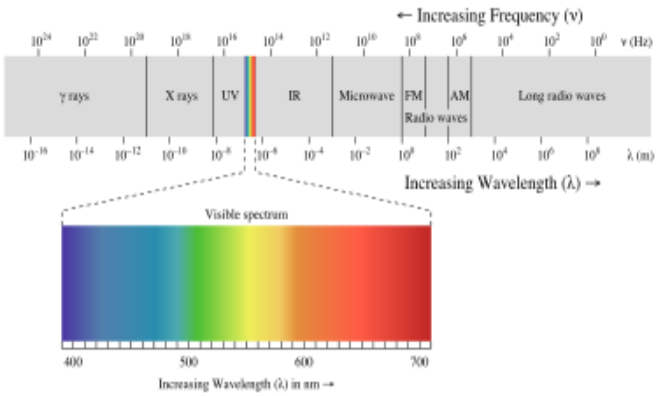

Fig.2: Light spectrum

Unlike incandescent and fluorescent bulbs, LEDs are solid-state electronics, meaning they can be controlled in much the same way as any other electronic component, and switched at a high speed. Instead of oscillating a Wi-Fi transmitter, VLC oscillates an LED bulb — and of course, on the receiving end there's a photo detector instead of an antenna.

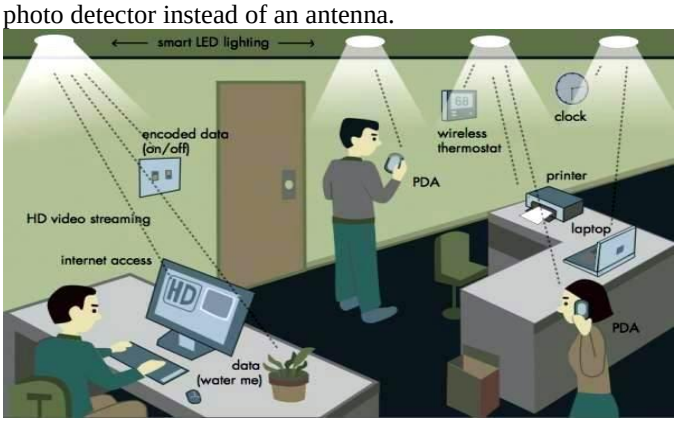

Fig.3: Theme of Li-Fi

A microchip is added to any humble LED bulb, making it blink on and off at a phenomenal speed, millions of times per second.

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It's this capability that allows LEDs to transmit data in a rapid stream of binary code that, although invisible to the naked eye, can then be detected by a light-sensitive receiver.

II. Methodology

Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. This varying property of optical current is used in Li-Fi setup. The operational procedure is simple-, if the LED is on, we transmit a digital 1, if it's off you transmit a 0. The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. The flashing of the light actually happens much faster that human eyes cannot detect, so the output appears constant, allowing for a Li-Fi data connection to resemble a simple LED bulb.

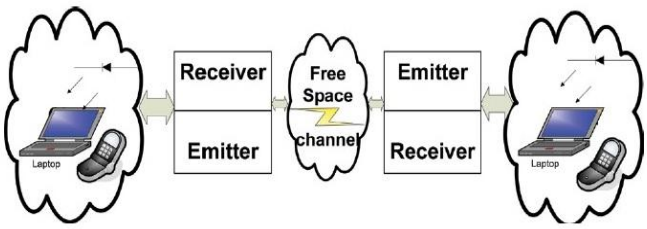

Fig.4: Basic Li-Fi communication

The LED lamp will hold a microchip that will do the job of processing the data. On one end all data on the internet will be streamed to a lamp driver. When LED is ON microchip convert digital data in form of light. On the other end this light is detected by the photo detector. Then this light is amplified and fed to the device. If the LED is ON, transmit a digital 1, if it's OFF you transmit a digit 0.

Fig.5: Li-Fi data transmission

Fig. 6 shows a simple emitter prototype-

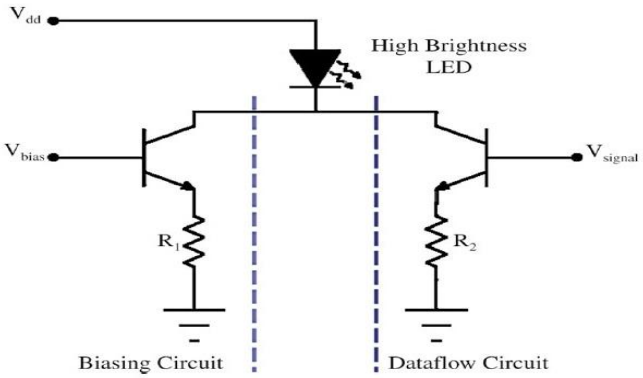

Fig.6: Simple Emitter prototype

The optical signal from LED transmitter is then intensity modulated (IM) with Direct Detection (DD) and generally On-Off Keying (OOK) modulation scheme is used to send information.

VLC receiver uses a positive-intrinsic-negative (PIN) photodiode. It does not have a high gain such has the avalanche photodiode (APD), but it can become an advantage in high noise environments, where the APD tends to saturate. The PIN is also cheaper and has a larger active area. Fig. 7 shows a simple emitter prototype-

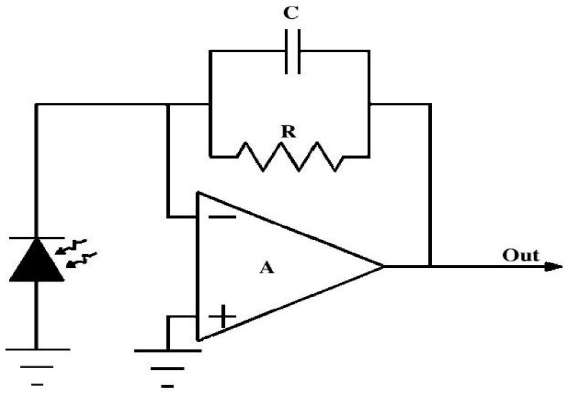

Fig.7: Simple Receiver prototype

III. Scopes and Possibilities of Li-fi

Visible light communication has a slew of advantages. In essence, Li-Fi can turn any LED lamp into a network connection. For the same reason, Li-Fi can be used in areas where there's extensive RF noise or where RF noise is generally prohibited (hospitals, airplanes). With reduced energy consumption and a longer life time, LEDs appear as a solution that cannot be overlooked to face up to the challenge of the CO2 emission reduction at the worldwide scale.

- Capacity: 10000 times more spectrum than radio waves.
- Efficiency: LED lights consume less energy, so it is highly efficient.
- Availability: It is available at all places where light is present.

- Security: Light waves do not penetrate through walls and hence cannot be intercepted and misused by anyone having any bad intention.
- Power save: It will save the power which is now using in conventional wireless communication as both light and data transfer can be done by only bulb.
- It will reduce the radio electromagnetic wave pollution.

Compared with conventional lighting methods, high brightness LEDs have higher power efficiency, long life expectancies, higher tolerance to humidity, lower heat generation and smaller sizes, which make these devices strong candidates for present and future lighting technology in case of wireless VLC.
In 2009, the US Federal Communications Commission warned of a looming spectrum crisis: because our mobile devices are so data-hungry we will soon run out of radio-frequency bandwidth. Li-Fi could free up bandwidth, especially as much of the infrastructure is already in place.

IV. Data Excellency with LEDs in Li-Fi
At the moment, commercial LEDs don't get much smaller than $1mm^2$. The Scottish researchers, however, are developing LEDs that are just $1\mu m^2$ — one micron; one thousand times smaller. Not only can we cram more of these micron-sized LEDs into the same space as a larger LED, but apparently they can also flicker on and off 1,000 times faster. A grid of 1,000 micro-LEDs, flashing 1,000 times faster, would be able to transmit data a million times faster than a normal LED by which we will able to enter in new communication world that is totally out of our imagination.

When this system will be symmetric and full duplex communication in excess of several Gbit/s in each direction then it will be thousand time faster than the conventional communication system.

V. Proposed Methodologies
Researchers at the Heinrich Hertz Institute in Berlin, Germany, have already reached transmitting up to 500Mbps over four meters (13 feet), or 120Mbps over 20 meters (67 feet) using VLC system. Moreover a novel modulation technique coined subcarrier index modulation (SIM)-OFDM was recently proposed. SIM-OFDM uses different frequency carrier states to convey information and leads to increased performance in comparison to conventional OFDM. Additionally, its innovative structure can lead to a decrease of the peak system power, which is highly beneficial in the context of optical wireless communication. Although SIM OFDM is already enhanced few days ago but we are making some new theme to go next step. Some method which may further increase the data transfer rate are given bellow-

- If we use more than two intensity level, the data transfer rate will be faster than the current system.
- It may contains 1000s or more of LED in array making it possible to transfer 1000s or more of data stream parallel at a very high speed. It will be more sophisticated technique which could dramatically increase VLC data rates on parallel data transmission, where each LED transmits a different data stream.
- Using mixtures of red, green and blue LEDs to alter the light's frequency, with each frequency encoding a different data channel. Such advancements promise a theoretical speed of 10 Gbps or more – meaning one can download a full high-definition film in just 30 seconds.
- The image sensor used in these devices is in fact an array of photodiodes (pixels) and in some applications its use may be preferred over a single photodiode. Such a sensor may provide either multi-channel communication (down to 1 pixel = 1 channel) or a spatial awareness of multiple light sources.
- Using several white LEDs with several intensity levels. Such as, we use 8 LEDs, then each of which will have separate intensity level and they will transmit 8 separate data streams.

Thanks to the Li-Fi technology, the 14 billion lamps in the world will become gradually green mobile internet masts that will permit to respond to the impressive increasing demand of mobile connectivity.

VI. Solicitations

- In hospitals, it is difficult to lay the optical fiber cables. Li-Fi can be used for modern medical instruments in operation theatre.
- In traffic signals Li-Fi can be used, which will communicate with the LED light of the cars and thus occurrences of accidents can be reduced.
- Thousands and millions of street lamps are deployed around the world. Each of these street lamps could be a free access point, provides up-to-date traffic info/warnings.
- Li-Fi can work under sea water where Wi-Fi fails completely, thereby throwing endless opportunities in military/navigation operations.
- In aircraft Li-Fi can be used for data transmission.
- It can be used in petroleum or chemical plant where other transmission or frequencies could be hazardous.
- In TV application, making interactive TV program.

VII. Conclusion
Visible Light Communication (VLC) using LEDs can become a viable option for last mile access and ubiquitous availability. 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. We just tries to make new concept to achieve more data transfer rate in Li-Fi which may made it as enormous VLC

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technology. Though the range of open research problems, we believe that the VLC system will be one of the most promising technologies for next-generation optical wireless communication.

Future Work

Our present work, thorough investigation and prototype development of VLC for traffic safety application under Visible Light Communication for advanced Driver Assistance System (DAS), car-to-car on road communication, long range parallel communication using VLC and making every bulb as Internet Access Point.

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