DATA TRANSMISSIONS THROUGH LI-FI NETWORKS

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Abstract—*Visible Light Communication (VLC) system based on white LEDs has emerged as an eco-friendly IT green technology using THz visible light spectrum in provision of both lighting and wireless access Nowadays people mostly use wireless network to accomplish their data sharing process. we are introducing concept of Li-Fi. Li-Fi stands for Light-Fidelity. Li- Fi technology, proposed by the German physicist— Harald Haas, provides transmission of data through illumination by sending data through an LED light bulb that varies in intensity faster than the human eye can follow. We focus on developing a Li-Fi based system and analyzes its performance with respect to existing technology Li-Fi provides better bandwidth, efficiency, availability and security than Wi-Fi and has already achieved blisteringly high speed in the lab. By leveraging the low-cost nature of LEDs and lighting units there are many opportunities to exploit this medium, we here present the future technology, where data for laptops, smart phones, and tablets will be transmitted through the light in a room. while providing efficient and low-cost lighting. To achieve the higher data rates (MHz), PLC channel is simulated using DMT-QAM modulation scheme.*

Keywords— Li-Fi, Wi-Fi, high-brightness LED, photodiode, wireless communication.

1. INTRODUCTION

Transfer of data from one place to another is one of the most important day-to-day activities. The current wireless networks that connect us to the internet are very slow when multiple devices are connected. As the number of devices that access the internet increases, the fixed bandwidth available makes it more and more difficult to enjoy high data transfer rates and connect to a secure network. But, radio waves are just a small part of the spectrum available for data transfer.A solution to this problem is by the use of Li-Fi. Li- Fi stands for Light-Fidelity. Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through an LED light bulb (shown in Fig. 1) that varies in intensity faster than the human eye can follow.

Li-Fi is the term some have used to label the fast and cheap wireless communication system, which is the optical version of Wi-Fi. Li-Fi uses visible light instead of Gigahertz radio waves for data transfer. The light, which he referred to as D-Light, can be used to produce data rates higher than 10 megabits per second which is much faster than our average broadband connection .

Li-Fi can play a major role in relieving the heavy loads which the current wireless systems face since it adds a new and unutilized bandwidth of visible light to the currently available radio waves for data transfer. Thus it offers much larger frequency band (300 THz) compared to that available in RF communications (300GHz). Also, more data coming through the visible spectrum could help alleviate concerns that the electromagnetic waves that come with Wi-Fi could adversely affect our health.

Li-Fi can be the technology for the future where data for laptops, smart phones, and tablets will be transmitted through the light in a room. Security would not be an issue because if you can‘t see the light, you can‘t access the data. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

2. CONSTRUCTION OF LI-FI SYSTEM

Li-Fi is a fast and cheap optical version of Wi-Fi. It is based on Visible Light Communication (VLC).VLC is a data communication medium, which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information wirelessly. The main components of Li-Fi system are as follows:

a) a high brightness white LED which acts as transmission source.
b) a silicon photodiode with good response to visible light as the receiving element.

LEDs can be switched on and off to generate digital strings of different combination of 1s and 0s. To generate a new data stream, data can be encoded in the light by varying the flickering rate of the LED. The LEDs can be used as a sender or source, by modulating the LED light with the data signal. The LED output appears constant to the human eye by virtue of the fast flickering rate of the LED. Communication rate greater than 100 Mbps is possible by using high speed LEDs with the help of various multiplexing techniques. VLC data rate can be increased by parallel data transmission using an array of LEDs where each LED transmits a different data stream. The Li-Fi emitter system consists of 4 primary sub- assemblies :

a) Bulb
b) RF power amplifier circuit (PA)
c) Printed circuit board (PCB)
d) Enclosure

The PCB controls the electrical inputs and outputs of the lamp and houses the microcontroller used to manage different lamp functions. A RF (radio-frequency) signal is

generated by the solid- state PA and is guided into an electric field about the bulb. The high concentration of energy in the electric field vaporizes the contents of the bulb to a plasma state at the bulb‘s center; this controlled plasma generates an intense source of light. All of these subassemblies (shown in Fig.) are contained in an aluminum enclosure.

The bulb sub-assembly is the heart of the Li- Fi emitter. It consists of a sealed bulb which is embedded in a dielectric material. This design is more reliable than conventional light sources that insert degradable electrodes into the bulb . The dielectric material serves two purposes. It acts as a waveguide for the RF energy transmitted by the PA. It also acts as an electric field concentrator that focuses energy in the bulb. The energy from the electric field rapidly heats the material in the bulb to a plasma state that emits light of high intensity and full spectrum .

There are various inherent advantages of this approach which includes high brightness, excellent color quality and high luminous efficacy of the emitter – in the range of 150 lumens per watt or greater. The structure is mechanically robust without typical degradation and failure mechanisms associated with tungsten electrodes and glass to metal seals, resulting in useful lamp life of 30,000+ hours. In addition, the unique combination of high temperature plasma and digitally controlled solid state electronics results in an economically produced family of lamps scalable in packages from 3,000 to over 100,000 lumens .

3. PRINCIPLE OF LI-FI TECHNOLOGY

The important segment of the Li-Fi technology is the high power Led lights, led can be turned on
& off quickly because the reaction time of the led
is lesser than 1 microsecond which cannot be detected by the human eye this will appear to be continues beam of light. This change from on state to off state in high frequencies enables the data transmition. On states ‘1’ and off states ‘0’the data can be encoded and modulation techniques can be done faster than the human eye can detect it. A photo detector can be used to receive the transmitted data from the light source and generates the original data. This method continuously receives the pulses of light and decode into the stream of data is referred as VLC (visible light communication).

Devices used in visible light communication

The components used into the Li-Fi communication purposes are Led lights or florescent light source and the photo detector. The light intensity of the Led and florescent bulb can be controlled by regulating the current applied to the light source. The usage of florescent lamps will help in generating the
10mb/s speed of data transfer but led light source provides the transmission speed of
500mb/s which is more faster response than that of florescent light so led lights are preferred to perform the visual light communication

4. IMPLEMENTATION

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 very property of optical current is used in
Li-Fi setup. The operational procedure is very simple-, if the LED is on, you 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 one has to do is to vary the rate at which the LED’s flicker depending upon the data we want to encode. Further enhancements can be made in this method, like using an array of LEDs for parallel data transmission, or 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 10Gbps in 30 second.

5. DESCRIPTION OF THE S YSTEM

The free space visible light beam is the advanced PHY layer of the hybrid LiFi-PLC system. These two technologies converge at MAC layer and it is called as inter- MAC. The cross-layer mechanism of the new integrated system consists of a 2.5 OSI layer able to hide the heterogeneity of communication technologies which constitute the home network. The inter-MAC layer is capable of forming a unified network as well as integrating its heterogeneous wired and wireless links. Functions such as quality-of-service control, load sharing, and dynamic path selection are made possible in such unified networks. The VLC system is standardized by IEEE 802.15.7 and the IEEE P1901 is a working group developing PLC medium access control and physical layer specifications. ITU-T adopted Recommendation G.hn/G.9960 as a standard for high-speed power line communications.

Composition of the System

The system shown in Fig. 1 proposes the bridging of LiFi over a power-line. The design in this study uses a 230 V/50 Hz power line network. The

configuration scheme for optimized illumination-coverage of an indoor space, proposed by Amirshahi and Kavehrad, can be followed to design a receiver with high field-of- view (FOV) to at least receive a LOS signal ray from one transmitter [9].

1) PLC Transmitter: The PLC transmitter, as shown in Fig. , mainly consists of the PLC module (APLC-485MA PLC chip), automatic voltage regulator (AVR based on 8- bitmicrocontroller ATmega16 chip), and level-shifter (MAX232 or ILX232N chip) to make the RS232 voltage level compatible with TTL signal level . The data is transmitted from the RS-232 cable to the power line through the exclusive PLC module. The PLC module offers a viable one-chip solution for switching of an access-point of LiFi into or out of a PLC network. The properly programmed microcontroller varies the duty cycle of the PWM signal which has the task of regulating the current in the LED.

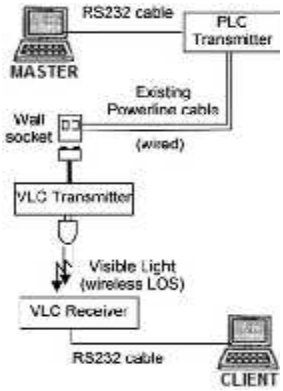


Figure . System architecture

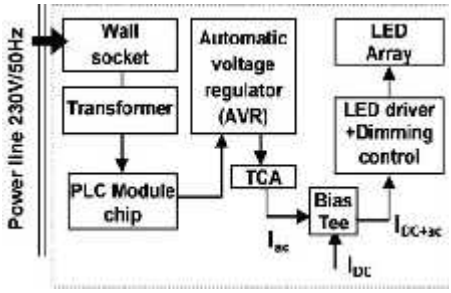
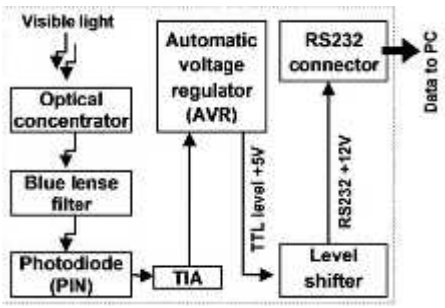


Figure . Block diagram of PLC receiver and VLC transmitter

2) VLC Receiver: At the receiver side as shown in Fig.



the practical down-conversion technique is direct detection (DD), in which a PIN photodiode sensor produces a current proportional to the received instantaneous power, i.e. proportional to the square of the received electric field. Blue filtering is used to remove the slow yellow light. The mA current from photodiode needs to be amplified by a transimpedance (TIA) amplifier (op-Amp LM324N). Then by making it to TTL-compatible as discussed previously, the data is reached to client by RS232 cable.Although the Fig. depicts a simplex master-to-client
communication, the duplex connection is viable. As like the master-to-client communication is realized through the voltage modulation on the power line, the client-to-master communication can be accomplished by modulating the current on the power line

6. RECENT ADVANCEMENTS IN LI-FI

Using a standard white-light LED, researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second . Using a pair of Casio smart phones, the technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten meters. A consortium called _Li-Fi Consortium' was formed in October 2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited amount of radio based wireless spectrum. According to the Li- Fi Consortium, it is possible to achieve more than 10 Gbps of speed, theoretically which would allow a high-

7. ADVANTAGES OF LI-FI

Li-Fi technology is based on LEDs or other light source for the transfer of data. The transfer of the data can be with the help of all kinds of light, no matter the part of the spectrum that they belong. That is, the light can belong to the invisible, ultraviolet or the visible part of the spectrum. Also, the speed of the communication is more than sufficient for downloading movies, games, music and all in very less time.Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi.

a) Capacity: Light has 10000 times wider bandwidth than radio waves [5]. Also, light sources are already installed. So, Li-Fi has got better capacity and also the equipments are already available.

b) Efficiency: Data transmission using Li-Fi is very cheap. LED lights consume less energy and are highly efficient.

c) Availability: Availability is not an issue as light sources are present everywhere. There are billions of light bulbs worldwide; they just need to be replaced with LEDs for proper transmission of data.

d) Security: Light waves do not penetrate through walls.

8. APPLICATIONS OF LI-FI

There are numerous applications of this technology, from public internet access through street lamps to auto-piloted cars that communicate through their headlights. Applications of Li-Fi can extend in areas where the Wi-Fi technology lacks its presence like medical

technology, power plants and various other areas. Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals where Wi-Fi is banned because they are prone to interfere with the radio waves. All the street lamps can be transferred to Li-Fi lamps to transfer data. As a result of it, it will be possible to access internet at any public place and street.Some of the future applications of Li-Fi are as follows:

a) Education systems: Li-Fi is the latest technology that can provide fastest speed internet access. So, it can replace Wi-Fi at educational institutions and at
companies so that all the people can make use of Li-Fi with the same speed intended in a particular area.

b) Medical Applications: Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes with the mobile and pc which blocks the signals for monitoring equipments. So, it may be hazardous to the patient's health. To overcome this and to make OT tech savvy Li-Fi can be used to accessing internet and to control medical equipments. This can even be beneficial for robotic surgeries and other automated procedures.

c) Cheaper Internet in Aircrafts: The passengers travelling in aircrafts get access to low speed internet at a very high rate. Also Wi-Fi is not used because it may interfere with the navigational systems of the pilots. In aircrafts Li-Fi can be used for data transmission. Li-Fi can easily provide high speed internet via every light source such as overhead reading bulb, etc. present inside the airplane.

d) Underwater applications: Underwater ROVs (Remotely Operated Vehicles) operate from large cables that supply their power and allow them to receive signals from their pilots above. But the tether used in ROVs is not long enough to allow them to explore larger areas. If their wires were replaced with light — say from a submerged, high-powered lamp — then they
would be much freer to explore. They could also use their headlamps to communicate with each other, processing data autonomously and sending their findings periodically back to the surface [1]. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

e) Disaster management: Li-Fi can be used as a powerful means of communication in times of disaster such as earthquake or hurricanes. The average people may not know the protocols during such disasters. Subway stations and tunnels, common dead zones for most emergency communications, pose no obstruction for Li-Fi [1]. Also, for normal periods, Li-Fi bulbs could provide cheap high-speed Web access to every street corner.

f) Applications in sensitive areas: Power plants need fast, inter-connected data systems so that demand, grid integrity and core temperature (in case of nuclear power plants) can be monitored. Wi-Fi and many other radiation types are bad for sensitive areas surrounding the power plants. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. This can save money as compared to the currently implemented solutions. Also, the pressure on a power plant‘s own reserves could be lessened. Li- Fi can also be used in petroleum or chemical plants where other transmission or frequencies could be hazardous.

g) Traffic management: In traffic signals Li- Fi can be used which will communicate with the LED lights of the cars which can help in managing the traffic in a better manner and the accident numbers can be decreased [1]. Also, LED car lights can alert drivers when other vehicles are too close.

h) Replacement for other technologies: Li-Fi doesn‘t work using radio waves. So, it can be easily used inthe places where Bluetooth, infrared, Wi-Fi, etc. are banned.

9. CONCLUSION

There are a plethora of possibilities to be gouged upon in this field of technology. If this technology becomes justifiably marketed then every bulb can be used analogous to a Wi-Fi hotspot to transmit data wirelessly. By virtue of this we can ameliorate to a greener, cleaner, safer and a resplendent future. The concept of Li-Fi is attracting a lot of eye-balls because it offers a genuine and very efficient alternative to radio based wireless. It has a bright chance to replace the traditional Wi-Fi because as an ever increasing population is using wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.

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