'Li-Fi': Data Transmission through illumination

By

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Abstract

It is often frustrating when the slow speed of network leads to limited connectivity and long processing hours while using wireless internet either at home network or coffee shop or airport or competing for bandwidth at a conference. As more and more users are tapped in with their devices, the clogged airwaves make it difficult to latch on a reliable signal.
What if we can use waves other than Radio waves to surf the internet? Radio wave seems to be fully exploited and other spectrum needed to be explored. In this direction, Dr Harold Haas, a German physicist proposed an idea called “Data through Illumination” in which he used fiber optics to send data through LED light bulb. The idea is similar as of infrared remote controls but far more powerful. D-Light can produce data rates faster than 10 mega bits per second, which is far quicker than average broadband connection. Hence a future can be envisioned having light as transmitting medium to our laptops, smart phones and tablets.

Keywords: Li-Fi, VLC, optical wireless, visible light communications

1. Introduction

As LED has many advantages such as long life, small volume, low power consumption and low heat radiation, it had been widely deployed in many applications, such as indoor lighting equipment, traffic lights, car indicator, displays and so on . White LED is expected to replace incandescent and fluorescent lights in the future and considered to be the next generation lighting source. LED can support high speed lighting and off. In this case, high speed data can be carried by the modulated light from the LED, which makes information transmission possible while lighting our life. When signals reach the receiver through the indoor wireless channel, the photodiode will convert the optical signals to electrical ones and the original information will be recovered. The visible light communication based on LED is a novel developing technique in the optical wireless communication field. Fig. 1 vividly represents a scene of indoor visible light communication system based on LED. Compared with the traditional wireless access technique, the proposed system has many advantages: easy installation, high data rate, no electromagnetic interference and so on . And it is believed that visible light communication based on white LED will play an important role in the next generation broadband access networks. Many research works about visible light communication had been performed in recent years . But most of the researches are in the simulation stage, experiment results are very few, and the research is still in its initial stage.

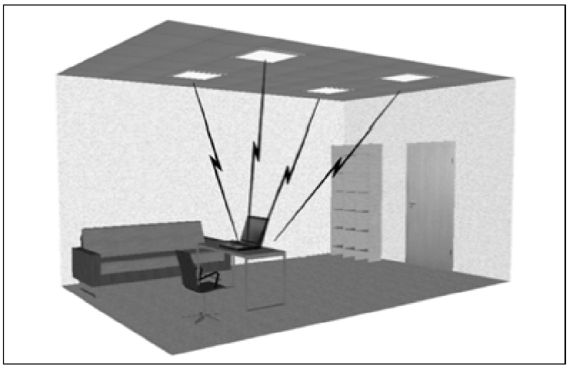


Fig. 1 Visible light communication system using LED

In this paper, we have designed a visible light communication system using one 3 W LED light as signal source, and demonstrated this visible light communication system in the room. Point-to-point transmission of this indoor wireless optical communication system has been realized at the distance as long as 1.5 m. Different transmission rates were compared and discussed.

2. System architecture

2.1 System model

The proposed VLC system is illustrated in Fig. 2.

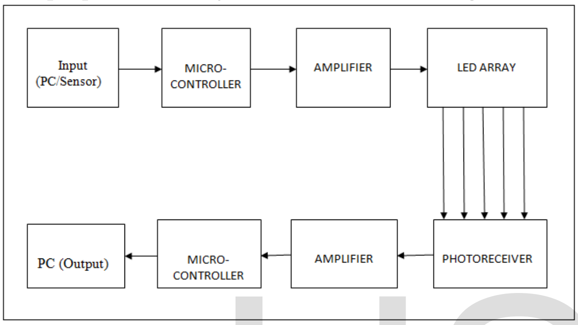
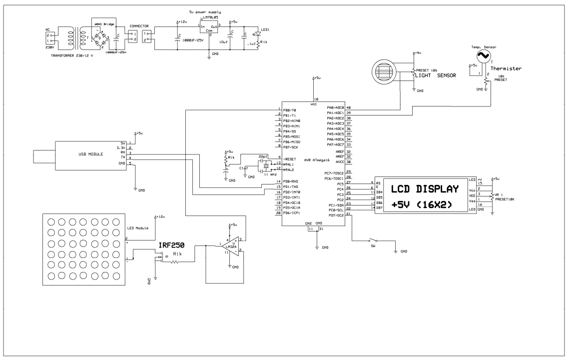


Fig. 2 Block diagram of VLC

The input data from personal computer (PC) transmitter is first coded into a string of pulse electrical signals by microcontroller unit (MCU) the TTL to USB interface circuit. Then, the amplified electrical signals are directed to the LED array directly through which electronic-to optical conversion is achieved. Because of the high on-off speed characteristic of LED, people cannot perceive the twinkling phenomena so that both lighting and information transmitting can be realized simultaneously. The generated optical signals carrying original information then delivered into the indoor wireless channel. At the receiver, pin photodiode or photo receiver will detect the optical signal and do the optical to-electronic conversion. Then the detected weak electrical signals are delivered into a receive circuit which contains preamplifier for signal amplification to meet the need of the following signal processing. The output data from receive circuit will arrive at the decoder device and be decoded into primary signal, and then sent to the PC receiver though the universal serial bus (USB) TTL to USB interface circuit.

2.2 Experimental circuit

Our experiment circuit diagram is illustrated in Fig. 3.



Fig, 3(a) Transmitter circuit diagram

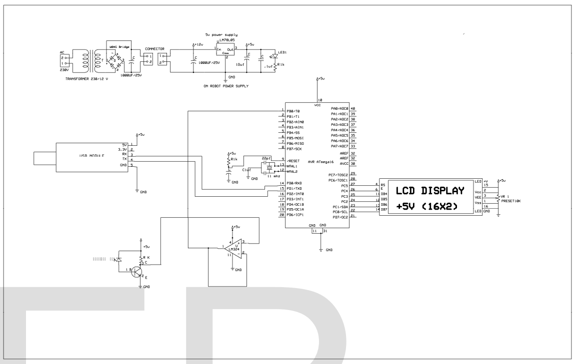


Fig.3(b) Receiver circuit diagram

Fig.3 Experimental circuit diagram of Li-Fi

Fig. 3 shows the full circuit diagram of our visible light communication system. The data from PC arrives at ATMega16 MCU through an interface circuit USB-I/0 2.0 port, whereas the data from sensors are directly given to the MCU. Then MCU will code the data binary bits. After that, the coded data is sent to the transmitter circuit. The transmit circuit drive the LED to emit the coded data. At the receiver, the receive circuit will process the received data and send them to decoder in which these data are decoded into the original data and sent to PC2 through interface circuit USB-I/0 2.0. Fig. 3(b) shows the designed receiver circuit diagram. 12 V constant power supply is used to supply steady current to LED light. The coded data is sent by the transmitter circuit through LED array.

PIN (S6775) is used as receiving photodiode because its fast response rate can be up to 15 MHz. The PIN detects the weak optical signal and changes them into weak electrical signal. And then the weak electrical signal will be amplified by the amplifier. After that, the signal will arrive at the current amplifier IC341 which can amplify received signal pulse. The IC341 has the ability to amplify the circuit current to 20–50 amplification factor. Then the data will arrive at MCU ATmega16 to further decode.

We have used XCTU softwares at both transmitter side and receiver side as terminals for data communication. XCTU is a free multi-platform application designed to enable developers to interact with RF modules through a simple-to-use graphical interface. It includes new tools that make it easy to set-up, configure and test RF modules.

3. Results and Discussion

We tested the illumination of the receiving surface in different distance between LED and receiver.

In XCTU the terminal window the line status all the options should turn green. These shows that the USB is connected and the transmitter and receiver are in sync with the PC's. Click on open port to start the communication between the transmitter or receiver and the PC. In order to send message from one PC to other, on the transmitter side click on assemble packet and type any message that is to be sent

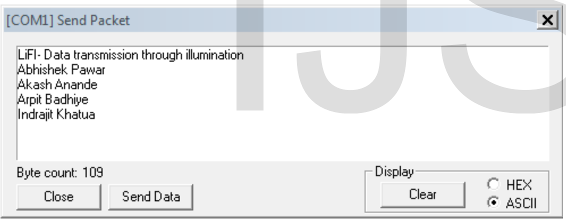


Fig.4(a) XCTU data to be transmitted as packet

After typing in the message as data click on send data. Thus the data sent by the transmitter is shown in XCTU transmitter terminal highlighted in blue color.

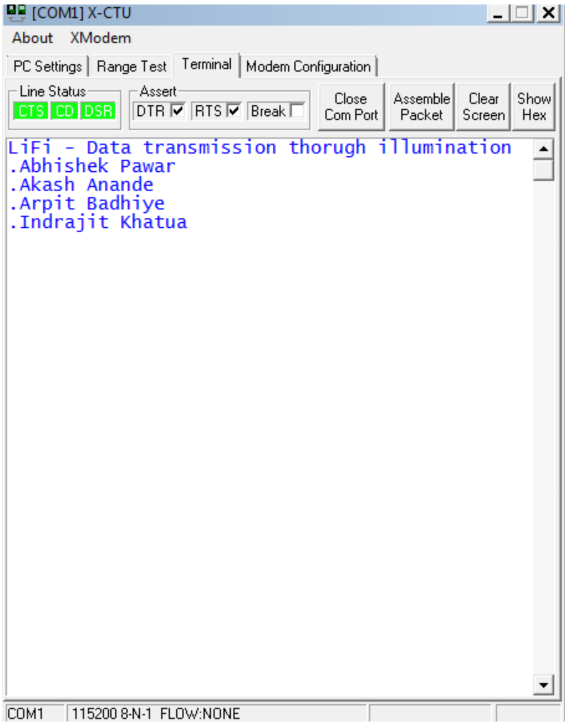


Fig.4(b) XCTU data transmitted by LED array

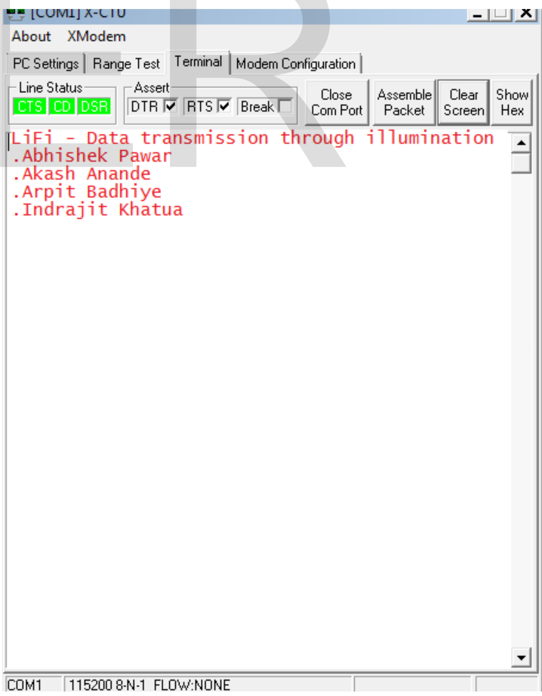


Fig.4(c) XCTU data received by photodiode

As soon as the data is transmitted by the LED array, the photodiode detects the optical signals and it is decoded back to original data which is shown at XCTU terminal of receiver side.

4. Comparison between Li-Fi & other technologies

LI-FI is a term of one used to describe visible light communication technology applied to high speed wireless communication. It acquired this name due to the similarity to WI-FI, only using light instead of radio. WI-FI is great for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage in confined area and for relieving radio interference issues, so the two technologies can be considered complimentary.

Technology	Speed	Data density
Wireless (current)		
• Wi-Fi – IEEE(802.11n)	150 Mbps	*
• Bluetooth	3 Mbps	*
• IrDA	4 Mbps	***
Wireless (future)		
• WiGig	2 Gbps	**
• Giga-IR	1 Gbps	***
• Li-Fi	>1Gbps	****

Fig 5 .Comparison with different technologies

The table also contains the current wireless technologies that can be used for transferring data between devices today, i.e. Wi-Fi, Bluetooth and IrDA. Only Wi-Fi currently offers very high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s (in theory the standard can go to 600Mbit/s) although in practice you receive considerably less than this. Note that one out of three of these is an optical technology.

5. How it is different?

Li-Fi technology is based on LEDs 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 data transmission achieved in research phases is incredibly high. Also, the technology overcomes challenges that are currently faced by Wi-Fi and other RF communications. Since the technology integrates wireless communication with LED illumination, it widens the scope of research in the field of high speed wireless connectivity.

6. Li-Fi Features

Li-Fi features include benefits to the capacity, energy efficiency, safety and security of a wireless system with a number of key benefits over Wi-Fi but are inherently a complementary technology.

6.1 Capacity

(i) Bandwidth: The visible spectrum is plentiful, unlicensed and free to use.

(ii) Data Density: Li-Fi can achieve about 1000 times the data density of Wi-Fi because visible light can be well contained in a tight illumination area whereas RF tends to spread out and cause interference.

(iii) High speed: Very high data rates can be achieved due to low interference, high device bandwidths and high intensity optical output.

6.2 Efficiency

(i) Low cost: Requires fewer components than radio technology.

(ii) Energy: LED illumination is already efficient and the data transmission requires negligible additional power.

(iii) Environment: RF transmission and propagation in water is extremely difficult but Li-Fi works well in this environment.

6.3 Safety & Security

(i) Safe: Life on earth has evolved through exposure to visible light. There are no known safety or health safety and health concerns.

(ii) Non-hazardous: The transmission of light avoids the use of radio frequencies which can dangerously interfere with electronic circuitry in certain environments.

(iii) Containment: It is difficult to eavesdrop on Li-Fi signals since the signal is confined to a closely defined illumination area and will not travel through walls.

7. Applications of Li-Fi

The dramatic growth in the use of LEDs (Light Emitting Diodes) for lighting provides the opportunity to incorporate Li-Fi technology into a plethora of LED environments.

Li-Fi is particularly suitable for many popular internet "content consumption" applications such as video and audio downloads, live streaming, etc. These applications place heavy demands on the downlink bandwidth, but require minimal uplink capacity. In this way, the majority of the internet traffic is off-loaded from existing RF channels, thus also extending cellular and Wi-Fi capacities.

There are many applications for Li-Fi. These include:

7.1 RF Spectrum Relief: Excess capacity demands of cellular networks can be off-loaded to Li-Fi networks where available. This is especially effective on the downlink where bottlenecks tend to occur.

7.2 Smart Lighting: Any private or public lighting including street lamps can be used to provide Li-Fi hotspots and the same communications and sensor infrastructure can be used to monitor and control lighting and data.

7.3 Mobile Connectivity: Laptops, smart phones, tablets and other mobile devices can interconnect directly using Li-Fi. Short range links give very high data rates and also provides security.

7.4 Hazardous Environments: Li-Fi provides a safe alternative to electromagnetic interference from radio frequency communications in environments such as mines and petrochemical plants.

7.5 Hospital & Healthcare: Li-Fi does not cause any electromagnetic interference and so does not interfere with any medical instruments

7.6 Aviation: Li-Fi can be used to reduce weight and cabling and add flexibility to seating layouts in aircraft passenger cabins where LED lights are already deployed. In-flight entertainment (IFE) systems can also be supported and integrated with passengers' own mobile devices.

7.7 Underwater Communications: Due to strong signal absorption in water, RF use is impractical. Acoustic waves have extremely low bandwidth and disturb marine life. Li-Fi provides a solution for short-range communications.

7.8 RF Avoidance: Some people claim they are hypersensitive to radio frequencies and are looking for an alternative. Li-Fi is a good solution to this problem.

7.9 Toys: Many toys incorporate LED lights and these can be used to enable extremely low-cost communication between interactive toys.

8. Conclusion

The possibilities are numerous and can be explored further. If his technology can be put into practical use, every bulb can be used something like a Wi-Fi hotspot to transmit wireless data and we will proceed toward the cleaner, greener, safer and brighter future. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage

of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

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