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Data Transmission on Li-Fi (Light-Fidelity) and It's Applications

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ABSTRACT

Li-Fi stands for Light Fidelity. The technology is very new and was proposed by the German physicist Harald Haas in 2011 TED (Technology, Entertainment, Design) Global Talk on Visible Light Communication (VLC). Li-Fi is a wireless optical networking technology that uses light emitting diodes (LEDs) for transmission of data. The term Li-Fi refers to visible light communication (VLC) technology that uses light as medium to deliver high-speed communication in a manner similar to Wi-Fi and complies with the IEEE standard IEEE 802.15.7. The IEEE 802.15.7 is a high-speed, bidirectional and fully networked wireless communication technology based standard similar to Wi-Fi's IEEE 802.11.

This paper focuses on Li-Fi, its applications, features and comparison with existing technologies like Wi-Fi etc. Wi-Fi is of major use for general wireless coverage within building, whereas Li-Fi is ideal for high density wireless data coverage in confined area and especially useful for applications in areas where radio interference issues are of concern, so the two technologies can be considered complimentary.

Li-Fi provides better bandwidth, efficiency, connectivity and security than Wi-Fi and has already achieved high speeds larger than 1 Gbps under the laboratory conditions. By leveraging the low-cost nature of LEDs and lighting units, there are lots of opportunities to exploit this medium. Li-Fi is the transfer of data through light by taking fibre out of fibre optics and sending data through LED light bulb.

Key words: IC LM386-1, Resistor (56Ω)-2, Resistor (10Ω)-1, Capacitor (10μF)-2, Capacitor (0.047μF)-1, Pot Resistor (10KΩ),Pot Resistor (100Ω)-1, Pot Resistor (220Ω)-1, LED (1W)-1, Battery (9V)-1, Switch-1, Solar panel-1, AUX cable-2, Speaker

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INTRODUCTION

In the era of overcrowded (data communication) world, Li-Fi is a new way of wireless communication that uses LED lights to transmit data wirelessly. Transmission of data is one of the most important day to day activities in the fast growing world. The current wireless networks that connect us to the Internet are very slow when multiple devices are connected. Also with the increase in the number of devices which access the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network.

Radio waves are just a small part of the electromagnetic spectrum available for data transfer. Li-Fi has got a much broader spectrum for transmission compared to conventional methods of wireless communications that rely on radio waves. The basic ideology behind this technology is that the data can be transferred through LED light by varying light intensities faster than the human eyes can perceive. This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum, instead of Gigahertz radio waves for data transfer.

The idea of Li-Fi was introduced for the first time by a German physicist Harald Hass in the TED (Technology, Entertainment, and Design) Global talk on Visible Light Communication (VLC) in July 2011, by referring to it as "data through illumination". He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. In simple terms, Li-Fi can be thought of as a light-based Wi-Fi i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. By adding new and unutilized bandwidth of visible light to the

currently available radio waves for data transfer, Li- Fi can play a major role in relieving the heavy loads which the current wireless system is facing. Thus it may offer additional frequency band of the order of 400 THz compared to that available in RF communication which is about 300 GHz. Also, as the Li-Fi uses the visible spectrum, it will help alleviate concerns that the electromagnetic waves coming with Wi- Fi could adversely affect our health.

By Communication through visible light, Li-Fi technology has the possibility to change how we access the Internet, stream videos, receive emails and much more. Security would not be an issue as data can't be accessed in the absence of light. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

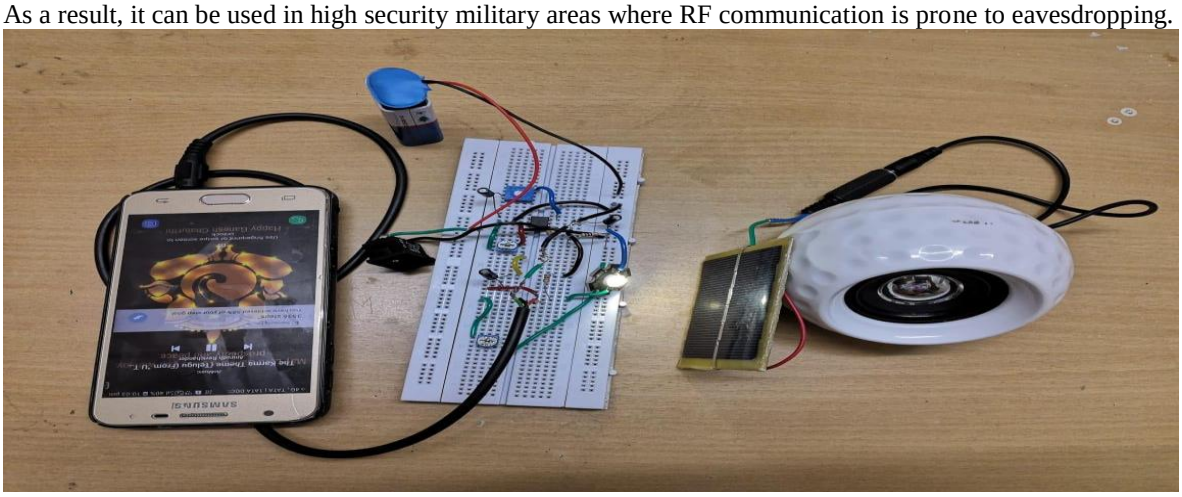

Fig. 1 Circuit of Li-Fi

Block Diagram

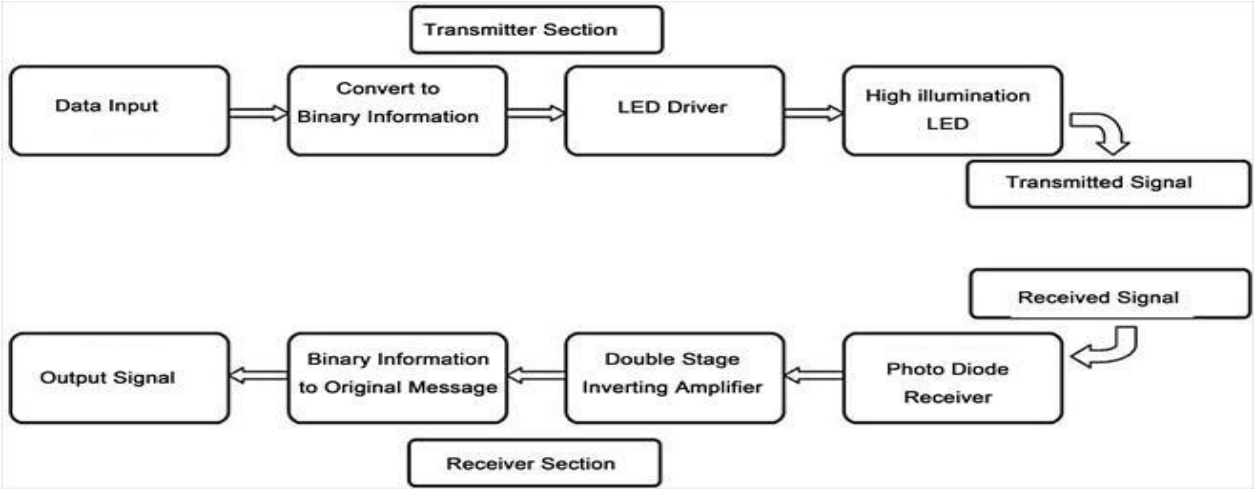

Fig. 2 Block diagram of Data Transmission on Li-Fi

Working of Li-Fi

Light Fidelity (Li-Fi) technology is a wireless communication system based on the use of visible light between the violet (800 THz) and red (400 THz). Unlike Wi-Fi which uses the radio part of the electromagnetic spectrum, Li-Fi uses the optical spectrum i.e. Visible light part of the electromagnetic spectrum. The principle of Li-Fi is based on sending data by amplitude modulation of the light source in a well-defined and standardized way. LEDs can be switched on and off faster than the human eyes can detect since the operating speed of LEDs is less than 1 microsecond. This invisible on-off activity enables data transmission using binary codes. If the LED is on, a digital '1' is transmitted and if the LED is off, a digital '0' is transmitted. Also these LEDs can be switched on and off very quickly which gives us a very nice opportunity for transmitting data through LED lights, because there are no interfering light frequencies like that of the radio frequencies in Wi-Fi. Li-Fi is thought to be 80% more efficient, which means it can reach speeds of up to 1Gbps and even beyond. Li-Fi differs from fiber optic because the Li-Fi protocol layers are suitable for wireless communication over short distances (up to 10 meters).This puts Li-Fi in a unique position of extremely fast wireless communication over short distances.

Fig. 3 Data Transmission through Light

Comparison between Li-Fi and Wi-Fi

Both Wi-Fi and Li-Fi can provide wireless Internet access to users, and both the technologies transmit data over electromagnetic spectrum. Li-Fi is a visible light communication technology useful to obtain high speed wireless communication. The difference is: Wi-Fi technology uses radio waves for transmission, whereas Li-Fi utilizes light waves. Wi-Fi works well for general wireless coverage within building/campus/compound, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and is free from interference issues unlike the Wi-Fi. Table I shows a comparison of Li-Fi with Wi-Fi.

Table -1 Comparison of Wi-Fi and Li-Fi

Parameter	**Li-Fi**	**Wi-Fi**
Spectrum Used	Visible Light	RF
Standard	IEEE 802.15.7	IEEE 802.11
Range	Based on Light Intensity (< 10m)	Based on Radio propagation & interference (< 300 m)
Data Transfer Rate*	Very high (~1 Gbps)	Low (100 Mbps-1 Gbps)
Power consumption	Low	High
Cost	Low	High
Bandwidth	Unlimited	Limited

Advantages of Li-Fi

Li-Fi, which uses visible light to transmit signals wirelessly, is an emerging technology poised to compete with Wi-Fi. Also, Li-Fi removes the limitations that have been put on the user by the Radio wave transmission such as Wi-Fi as explained above vide 4.1. Advantages of Li-Fi technology include:

- Efficiency*:* Energy consumption can be minimized with the use of LED illumination which are already available in the home, offices and Mall etc. for lighting purpose. Hence the transmission of data requiring negligible additional power, which makes it very efficient in terms of costs as well as energy.
- High speed*:* Combination of low interference, high bandwidths and high-intensity output, help Li-Fi provide high data rates i.e. 1 GBPS or even beyond.
- *Availability:* Availability is not an issue as light sources are present everywhere. Wherever there is a light source, there can be Internet. Light bulbs are present everywhere– in homes, offices, shops, malls and even planes, which can be used as a medium for the data transmission.
- Cheaper: Li-Fi not only requires fewer components for its working, but also uses only a negligible additional power for the data transmission.
- Security*:* One main advantage of Li-Fi is security. Since light cannot pass through opaque structures, Li- Fi internet is available only to the users within a confined area and cannot be intercepted and misused, outside the area under operation.
- Li-Fi technology has a great scope in future. The extensive growth in the use of LEDs for illumination indeed provides the opportunity to integrate the technology into a plethora of environments and applications.

Disadvantages of Li-Fi

- Light cannot penetrate through the objects or walls
- High installation cost of VLC systems
- Interferences from external sources like sun, light, normal bulbs.
- Used for broadcast and it is difficult to uplink.

Limitations of Li-Fi

Some of the major limitations of Li-Fi are:

- Internet cannot be accessed without a light source. This could limit the locations and situations in which Li-Fi could be used.
- It requires a near or perfect line-of-sight to transmit data.
- Opaque obstacles on pathways can affect data transmission
- Natural light, sunlight, and normal electric light can affect the data transmission speed
- Light waves don't penetrate through walls and so Li-Fi has a much shorter range than Wi-Fi
- High initial installation cost, if used to set up a full-fledged data network.
- Yet to be developed for mass scale adoption.

Applications of Li-Fi

- Education systems*:* Li-Fi is the latest technology that can provide fastest speed for Internet access. So, it can augment/replace Wi-Fi at educational institutions and at companies so that the people there can make use of Li-Fi with the high speed.
- Medical Applications*:* Operation theatres (OTs) do not allow Wi-Fi due to radiation concerns. Usage of Wi-Fi at hospitals interferes/blocks the signals for monitoring equipment's. So, it may have hazardous effect to the patient's health, due to improper working of medical apparatus. To overcome this and to make OT tech savvy Li-Fi can be used to access internet and also to control medical equipment's. This will be beneficial for conducting robotic surgeries and other automated procedures.
- Cheaper Internet in Aircrafts*:* The passengers travelling in aircrafts get access to low speed Internet that too at a very high price. 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.
- 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. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military underwater operations.
- 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.
- 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. The Radio communication interference is considered to be bad for such's own reserves (power consumption for Radio communications deployments) will be lessened.
- Traffic management*:* In traffic signals Li-Fi can be used to communicate with passing vehicles (through the LED lights of the cars etc.) which can help in managing the traffic in a better manner resulting into smooth flow of traffic and reduction in accident numbers. Also, LED car lights can alert drivers when other vehicles are too close.
- Mobile Connectivity*:* Mobiles, laptops, tablets, and other smart phones can easily connect with each other. The short-range network of Li-Fi can yield exceptionally high data rates and higher security.
- Li-Fi doesn't work using radio waves. So, it can be easily used in the places where Bluetooth, infrared, Wi-Fi, etc. are banned.

Fig. 4 Applications of Li-FI

Future Scope

As light is everywhere and free to use, there is a great scope for the use and evolution of LiFi technology. If this technology becomes mature, each Li-Fi bulb can be used to transmit wireless data. As the Li-Fi technology becomes popular, it will lead to a cleaner, greener, safer communications and have a bright future and environment. The concept of Li-Fi is deriving many people as it is free (require no license) and faster means of data transfer. If it evolves faster, people will use this technology more and more. Currently, LBS (location Based Service) or Broadcast solution are commercially available. The next step could be a Li-Fi WLAN for B2B market with high added value on specific business cases and could grow towards mass market. In the long term, the Li- Fi could become an alternative solution to radio for wireless high data rate room connectivity and new adapted service, such as augmented or virtual reality.

CONCLUSION

Although there's still a long way to go to make this technology a commercial success, it promises a great potential in the field of wireless internet. A significant number of researchers and companies are currently working on this concept, which promises to solve the problem of lack of radio spectrum, space and low internet connection speed. By deployment of this technology, we can migrate to greener, cleaner, safer communication networks. The very concept of Li-Fi promises to solve issues such as, shortage of radio-frequency bandwidth and eliminates the disadvantages of Radio communication technologies. Li-Fi is the upcoming and growing technology acting as catalyst for various other developing and new inventions/technologies. Therefore, there is certainty of development of future applications of the Li-Fi which can be extended to different platforms and various walks of human life.

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