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# Light Fidelity (LiFi)Technology in Wireless Data Communication

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**Abstract:**

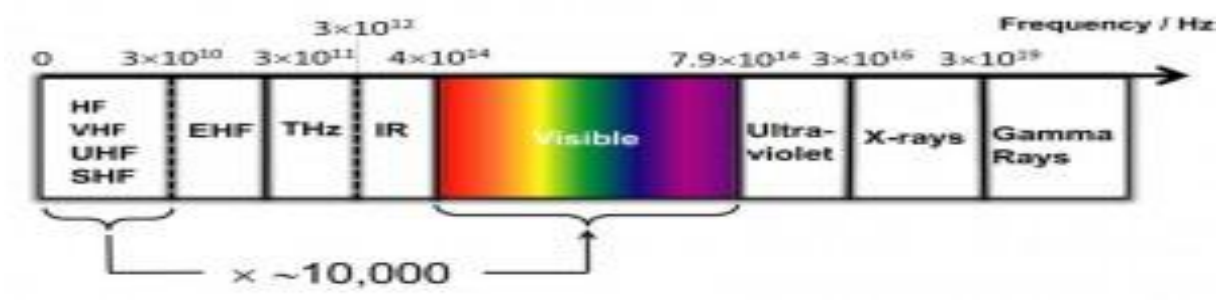
Light Emitting Diodes (LED) are used indifferent areas of everyday life. The advantage of this device is that in addition to their lightening capabilities, it can be used for data transmissions as well. Nowadays almost all the peoples are using internet to accomplish their task through wired or wireless network. As number of users are increases in using wireless network, speed decreases. Though Wi-Fi gives us speed up to 150mbps as per IEEE 802.11n, which is not sufficient to accommodate number of desired users. To remedy this limitation of Wi-Fi, we are introducing the new concept of Li-Fi technology. Li-Fi stands for the Light Fidelity. 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, from public internet access through street lamps to auto-piloted cars that communicate through their headlights..

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

## Introduction:

Li-Fi technology is a ground-breaking light-based communication technology, which makes use of light waves instead of radio technology to deliver data. Using the visible light spectrum, Li-Fi technology can transmit data and unlock capacity which is 10,000 times greater than that available within the radio spectrum.

The visible light spectrum is plentiful, free and unlicensed, mitigating the radio frequency spectrum crunch effect.



**The future internet**

Li-Fi technology will in future enable faster, more reliable internet connections, even when the demand for data usage has outgrown the available supply from existing technologies such as 4G, LTE and Wi-Fi. It will not replace these technologies, but will work seamlessly alongside them.

Using light to deliver wireless internet will also allow connectivity in environments that do not currently readily support Wi-Fi, such as aircraft cabins, hospitals and hazardous environments.

Light is already used for data transmission in fibre-optic cables and for point to point links, but Li-Fi is a special and novel combination of technologies that allow it to be universally adopted for mobile ultra high speed internet communications.

**Overview of LI-FI Technology**

LI-FIstands for "Light Fidelity". The technology uses an LED light bulb that varies in intensity faster than the human eye can follow to send data through illumination. The light that zips data across the Internet's backbone used to stop along way from the data's final destination but now it goes all the way to our homes. The LI-FI technology takes the last step and takes the light all the way to the computer or TV, projecting it through the air over the last few meters and only converting it to an electronic signal at the end.

Since LI-FI uses visible light instead of radio waves as the medium of communication, LI-FI is considered as the optical version of WI-FI. LI-FI is an important component of the Internet of Things (IoT), in which everything is connected to the internet. LED lights are used as access points in case of IoTs.Such indoor optical wireless probably wouldn't replace Wi-Fi, but with a potential for data rates of 3 terabits per second and up, it could certainly find itsuses. Wi-Fi, by contrast, tops out at about 7 Gb/s. And with light, there's no worry about sticking to a limited set

of radio frequencies. If someone is in the optical window, he will have virtually unlimited bandwidth and unlicensed spectrum. With the increasing use of Wi-Fi, the existing radio frequency is getting blocked slowly and simultaneously, there is an increasing number of people who want to connect to the internet. Wireless radio frequencies are getting higher, complexities are increasing and RF interferences continue to grow. The LI-FI technology helps us to overcome these problems.

LI-FI uses the Visible Light Communication (VLC). Visible light communication is a data communications medium which uses visible light between 400and 800



THz (780–375nm). VLC is a subset of optical wireless communications technologies. The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to

transmit signals at 10kbit/s, or LEDs for up to 500Mbit/s. Low rate data transmissions at 1 and 2 kilometres (0.6 and 1.2mi) were demonstrated. Specially designed electronic devices generally containing a photodiode receive signals from light sources, although in some cases a cell phone camera or a digital camera will be sufficient.

**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 theflickering 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

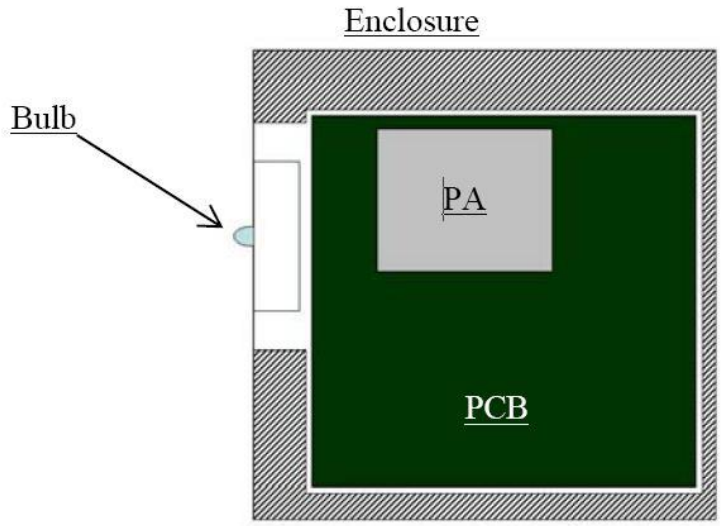
b)RF power amplifier circuit (PA)

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 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 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.

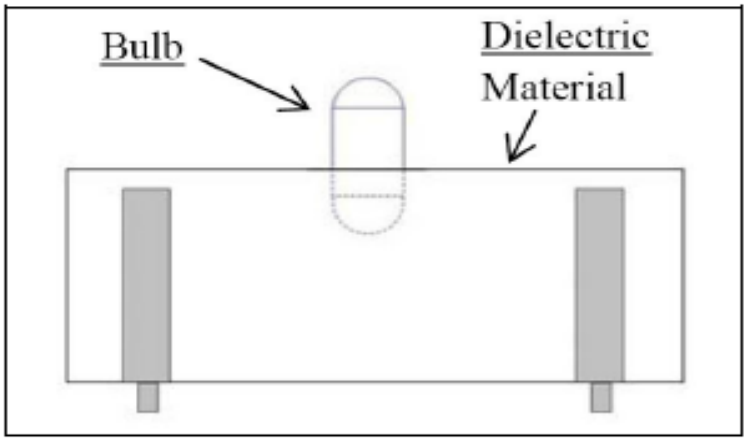



Figure shows the bulb sub-assembly.

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

The working of Li-Fi is very simple. There is a light

emitter on one end, for example, an LED, and a photo detector (light sensor) on the other. The photo detector registers a binary one when the LED is on; and a binary zero if the LED is off. To build up a message, flash the LED numerous times or use an array of LEDs of perhaps a few different colors, to obtain data rates in the range of hundreds of megabits per second. The block diagram of Li-Fi system is shown in Fig. 4.

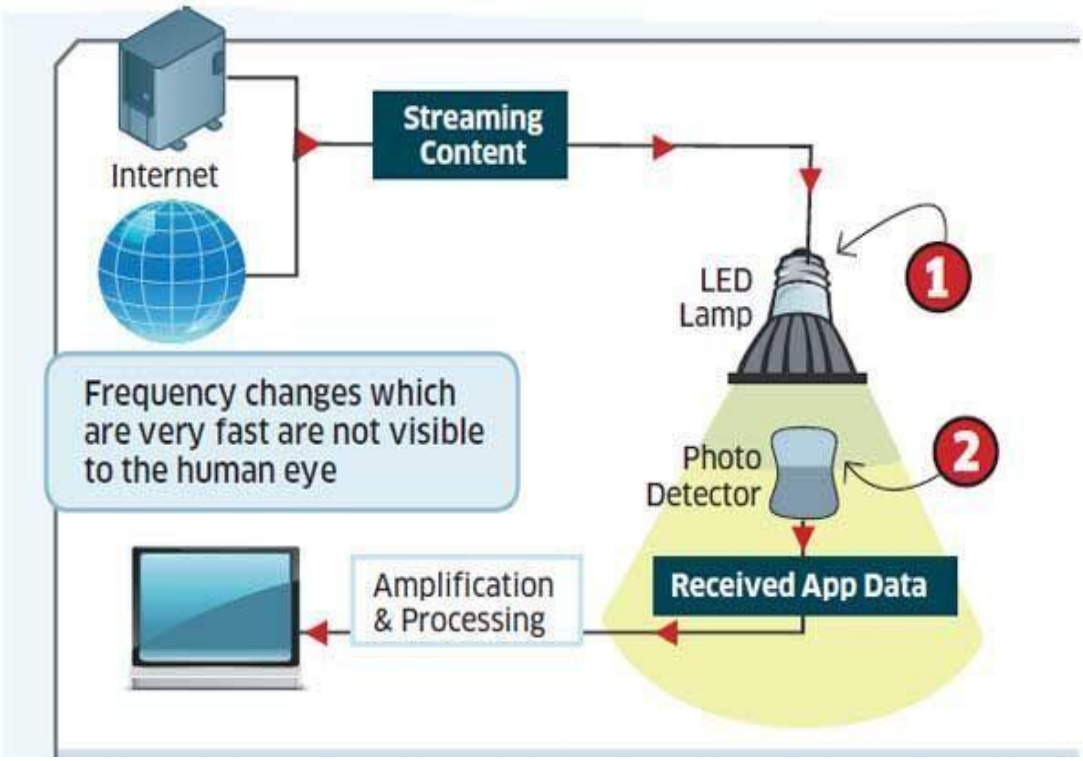
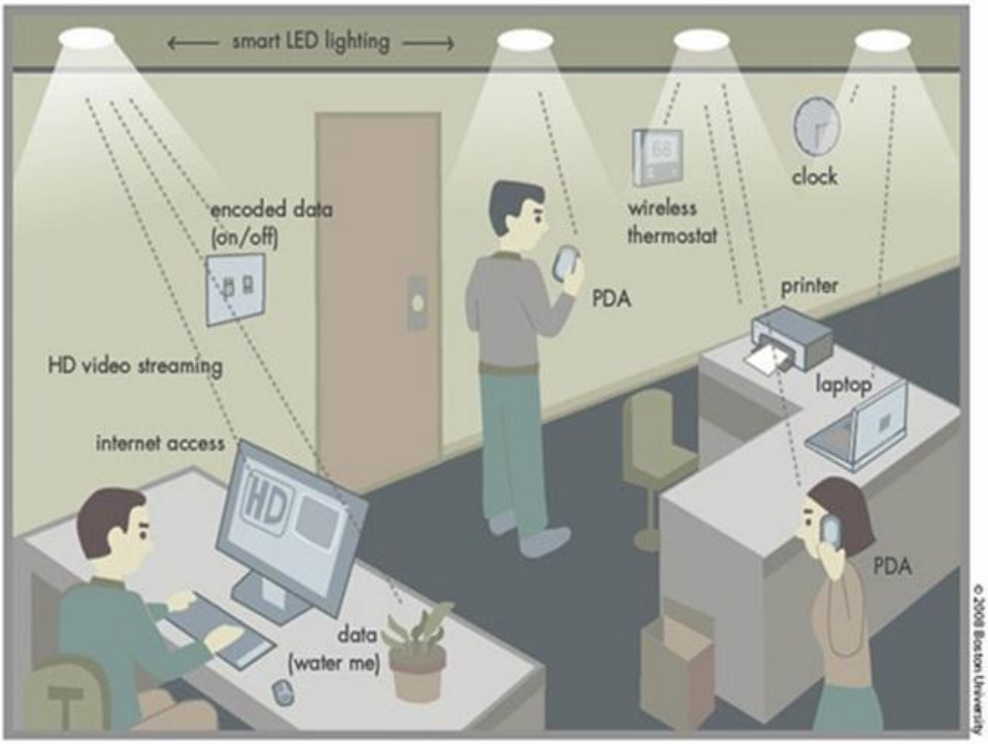



Fig. 4. Block diagram of Li-Fi system

The data can be encoded in the light by varying the flickering rate at which the LEDs flicker on and off to generate different strings of 1s and 0s.The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans. Light-emitting diodes (commonly referred to as LEDs and found in traffic and street lights, car brake lights, remote control units and countless other applications) can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is in fact 'flickering'.

The on-off activity of the bulb which seems to be invisible enables data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. By varying the rate at which the LEDs flicker on and off, information can be encoded in the light to different combinations of 1s and 0s. This method of using rapid pulses of light to transmit information wirelessly is technically referred to as Visible Light Communication (VLC), though it is popularly called as Li-Fi because it can compete with its radio-based rival Wi-Fi. Figure 5 shows a Li-Fi system connecting devices in a room.




Li-Fi system connecting devices in a room

**COMPARISON BETWEEN LI-FI &WI-FI**

Li-Fi is the name given to describe visible light communication technology applied to obtain high speed wireless communication. It derived this name by virtue of the similarity to Wi-Fi. Wi-Fi works well for general wireless coverage within buildings, and Li-Fi is ideal for high density wireless data coverage inside a confined area or room and for relieving radio interference issues.

Table I shows a comparison of transfer speed of various wireless technologies. Table II shows a comparison of various technologies that are used for connecting to the end user. Wi- Fi currently offers high data rates. The IEEE 802.11.n in most implementations provides up to 150Mbit/s although practically, very less speed is received.

TABLE I. COMPARISON OF SPEED OF VARIOUS WIRELESS TECHNOLOGIES

| **Technology** | **Speed** |
|---|---|
| Wi-Fi – IEEE 802.11n | 150 Mbps |
| Bluetooth | 3 Mbps |
| IrDA | 4 Mbps |
| Li-Fi | >1 Gbps |

TABLE II. COMPARISON OF TECHNOLOGIES USED FOR CONNECTING TO THE END USER

| .Technology | Connection | Security | Reach | Impact | Cost | Bandwidth Expansion |
|---|---|---|---|---|---|---|
| Wi-Fi | Wireless-EMF | Good | Excellent | unknown | Good | Limited |
| Hardwired | Cables | Excellent | Fair | None | Good | Limited |
| Li-Fi | Wireless-Light | Excellent | Excellent | None | Low | Exceptional |

***Problems in Wi-Fi***

The following are the basic issues with radio waves:

a) **Capacity**: Wireless data is transmitted through radio waves which are limited and expensive. It has a
limited bandwidth. With the rapidly growing world and development of technologies like 3G, 4G and so
on we are running out of spectrum.

b) **Efficiency**: There are 1.4 million cellular radio base stations that consume massive amount of energy. Most of the energy is used for cooling down the base station instead of transmission. Therefore efficiency of such base stations is only 5%.

c) **Availability**: Availability of radio waves is a big concern. It is not advisable to use mobile phones in
aero planes and at places like petrochemical plants and petrol pumps.

d) **Security**: Radio waves can penetrate through walls. They can be intercepted. If someone has knowledge and bad intentions, they may misuse it. This causes a major security concern for Wi-Fi.

***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 presents 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. So, they can‘t be intercepted and misused.

**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 LiFi
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. 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 fo 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 in the places where Bluetooth, infrared, Wi-Fi, etc. are banned.

**Application of Li Fi Technology**

- You Might Just Live Longer
- Airlines
- Smarter Power Plants
- Undersea Awesomeness
- It Could Keep You Informed and Save Lives

**Advantages of Li Fi Technology**

- Li-Fi can solve problems related to the insufficiency of radio frequency bandwidth because this technology uses Visible light spectrum that has still not been greatly utilized.
- High data transmission rates of up to 10Gbps can be achieved.
- Since light cannot penetrate walls, it provides privacy and security that Wi-Fi cannot.
- Li-Fi has low implementation and maintenance costs.

**Disadvantages of Li Fi Technology**

- Light can’t pass through objects.
- High installation cost of the VLC systems.
- Interferences from external light sources like sun, light, normal bulbs, opaque materials.

## VII. 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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