

# A Study on LiFi Wireless Visible Light Communication

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**Abstract - Li-Fi Light Fidelity– IEEE 802.15 Standard is high-speed, bidirectional, networked and mobile wireless communications using light. This technology is wireless and uses visible light or infra-red and near ultraviolet (instead of radio frequency waves) spectrum for communication. This form of Visible light communication (VLC) and optical wireless communications (OWC) helps in replacement of data broadcasting. It is measured to be about 100 times faster than Wi-Fi, reaching speeds of 224 gigabits per second. The Visible Light Communication (VLC) is the best solution to overcome the problems faced in RF system like bandwidth, availability, health, security. VLC uses visible light region of electromagnetic spectrum, which is 10000 times broader than RF region. Like Wi-Fi VLC has Light Fidelity (Li-Fi) which uses light as source. The VLC works by modulating the intensity of light from LED array which is detected by photo detector (PD) and then demodulated to electronic signal. Li-Fi is now part of Visible Light Communications (VLC) PAN IEEE 802.15.7 standard. VLC signals work by switching bulbs on and off within nanoseconds which is too quick to be noticed by a human eye. More sophisticated techniques could dramatically increase VLC data rate. Li-Fi is an emerging technology that could see specialized LED (Light Emitting Diode) light bulbs providing low-cost wireless internet connectivity almost everywhere.**

**Key words - LED (Light Emitting Diode), VLC (Visible Light Communication), OWC (Optical wireless communications), Li-Fi, Wi-Fi.**

## I. INTRODUCTION

Li-fi technology uses VLC. It is similar to Wi-Fi technology with RF communication. The term Li-fi was first coined by Harald Haas, a German physicist. Li-Fi or light fidelity, refers to 5G visible light communication systems using light from light emitting diodes(LED) as a medium to deliver networked, mobile, high-speed communication in a similar manner as Wi-Fi. Li-fi operates in the range of terahertz and it is free from the spectrum license. Visible light communication is a data communication medium using visible light as carrier. It is one of the parts of optical wireless communication (OWC). Optical communication becomes cost effective because of the use of light which is freely available everywhere. The visible light communication is done with LED. Visible light communication is a data communication medium using visible light as carrier. It is one of the parts of optical wireless communication (OWC). Optical communication becomes cost effective because of the use of light which is freely available everywhere. The visible light communication is done with LED. The intensity of light is modulated such that a human eye can't follow it. A light detector with interference prevention from other source is used. It is acting as receiver which can demodulate the light signal into electronic signal. It differs from infrared (IR) and ultra violet (UV) as light used for lighting is also used for communication. VLC is mostly used for indoor communication.

The most important requirement is of light source with ability of very fast on-off switching. A novel modulation technique like unipolar orthogonal frequency division multiplexing (UOFDM) is used. Li-Fi to transmit signal and light reflected off of the walls can achieve 70Mbps. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking. Li-Fi is the transmission of data through illumination by taking the fibre out of fibre optics by sending data through a LED light bulb. Li-Fi can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military/navigation operations.

## II. WORKING OF LI-FI

Li-Fi or Light Fidelity is a technology that uses light emitting diodes to transmit data wirelessly. The functioning of new Li-Fi technology is just simple. That is a light source at one end like a LED and a photo detector (Light Sensor) on the other end. The LED is connected to the internet through the modem and the receiver decodes the information, which is then displayed on the device. When a constant current is applied to an LED light bulb a constant stream of photons are emitted from the bulb which is observed as visible light. If the current is varied slowly the output intensity of the light dims up and down. Because LED bulbs are semi-conductor devices, the current, and hence the optical output, can be modulated at extremely high speeds which can be detected by a photo-detector device and converted back to electrical current.

This brilliant idea was first showcased by Harald Haas from University of Edinburgh, UK, in his TED Global talk on VLC. He explained, "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.” Since Li-Fi uses just the light, it can be used safely in aircrafts and hospitals that are prone to interference from radio waves. This can even work underwater where Wi-Fi fails completely, thereby throwing open endless opportunities for military operations.

Radio waves are replaced by light waves in a new method of data transmission which is being called Li-Fi. Light-emitting diodes can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously. 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'. This invisible on-off activity enables a kind of data transmission using binary codes: switching on an LED is a logical '1', switching it off is a logical '0'. Information can therefore be encoded in the light by varying the rate at which the LEDs flicker on and off to give different strings 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's potential to compete with conventional Wi-Fi has inspired the popular characterisation Li-Fi. The working of VLC and Li-Fi technologies are shown in figure 1 and 2 respectively.

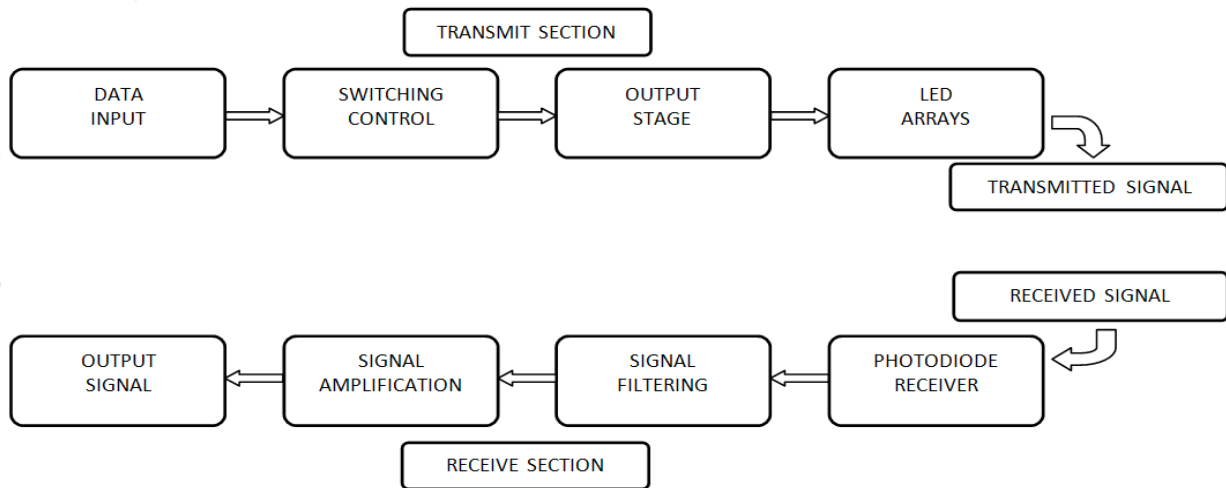


Fig 1: Block Diagram for VLC

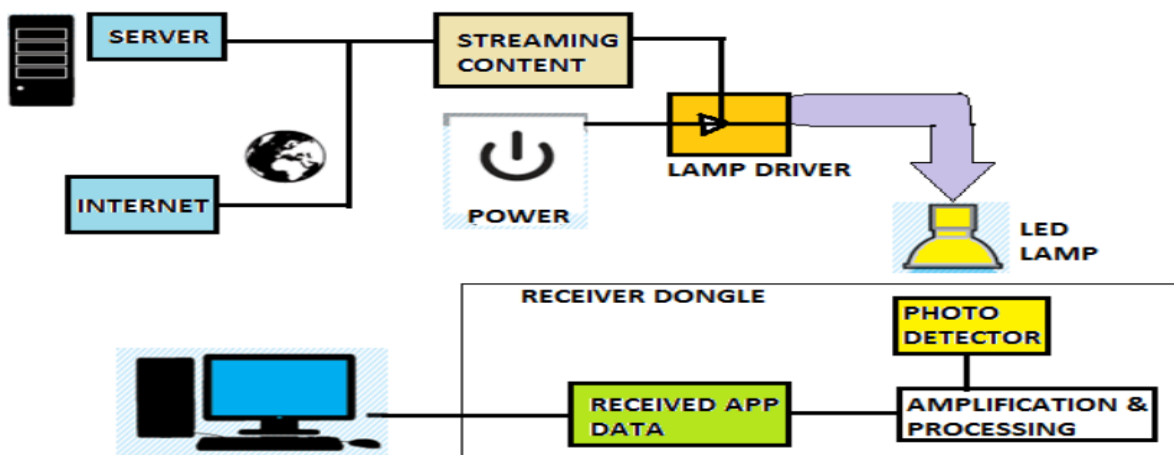


Fig 2: Working of Li-Fi Technology

**III. DIFFERENCE BETWEEN LI-FI & WI-FI**

Li-Fi is similar to Wi-Fi. LI-FI is used to describe visible light communication technology applied to high speed wireless communication. Wi-Fi uses radio waves whereas Li-Fi uses light. 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. The technical differences between various technologies are presented in table 2. The difference between Li-Fi and Wi-Fi is in table 1.

**Table 1: Differences between Li-Fi and Wi-Fi Technologies**

Parameter	Li-Fi	Wi-Fi
Spectrum Used	Visual Light	RF
Standard	IEEE 802.15	IEEE 802.11
Range	Based on light intensity	Not more than 150 meters
Data transfer rate	Based on LED >1 Gbps	10Mbps
Power Consumption	Low	High
Cost	Low	High

Security	Less secure than Wi-Fi	More secure
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**Table 2: Technical Differences between present and future technologies**

Technology	Speed	Data Density
<b>Wireless (Present)</b>		
Wi-Fi IEEE – 802.11n	150 Mbps	*
Bluetooth	3 Mbps	*
IrDA	4 Mbps	***
<b>Wireless (Future)</b>		
WiGig	2 Gbps	**
Giga-IR	1 Gbps	***
Li-Fi	>1 Gbps	****

**IV. OSI REFERENCE LAYERS FOR VLC COMMUNICATION**

For any communication the two basic parts are sender and receiver. In VLC, a LED bulb is used as sender. The sender signal is controlled either by fast ON/OFF switching of LED. The photo diode is used as a receiver to detect this signal. The vital layers in VLC OSI model is Physical Layer (PHY) and Data Link Layer (DLL). These are important for sending and receiving the light signal. The Media Access Control (MAC) and PHY layers are same for both transmitter and receiver part.

**The Physical Layer**

In VLC this layer functions same as in the OSI model. It defines the electrical and physical specifications of hardware used. The communication on Physical layer is done with small units of data called as packets. According to the data rates the physical layer is categorized as, PHY 1: It is low data rate (12 to 267 kbps) physical layer It is used for outdoor operation. PHY 2: It have moderate data rate of 1.25 to 96 Mbps. It is used for indoor applications. PHY 3: It is with high data rate of 12 to 96 Mbps. It is used for lightning sources and detectors.

**The Data Link Layer**

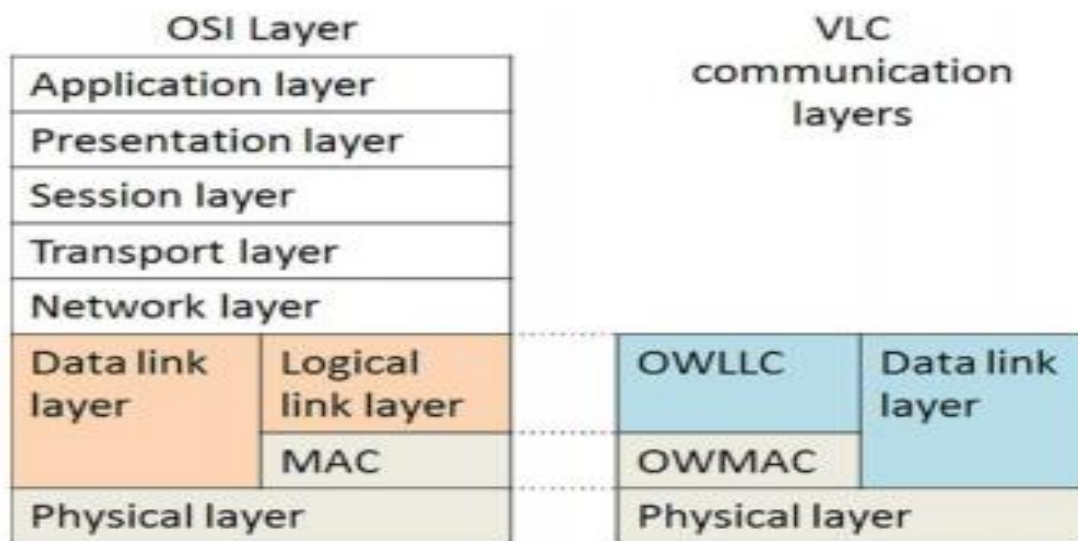
This layer uses the services of physical layer to send and receive data bits over communication channel. According to the architecture used in IEEE 802.15.7 project this layer is divided into two sub-layers as an Optical Wireless Logic Link Control (OWLLC) and Optical Wireless Media Access Control (OWMAC).

**Optical Wireless LLC**

It confirms and controls the logical links between devices on a network. With DLL it allows the interconnection of other technologies and provides services to network layer.

**Optical Wireless MAC**

The media of communication may be simplex, half duplex or full duplex, OWMAC confirms the control over it. With the use of OWMAC protocol working terminals and connected devices are controlled.



**Figure 3: OSI Layer reference model for VLC communication layer**

**V. APPLICATIONS OF LI-FI TECHNOLOGY**

**Li-Fi on Medical care:** Medical technology has lagged behind the rest of the wireless world. Operating rooms do not allow Wi-Fi over radiation concerns, and there is also that whole lack of dedicated spectrum. While Wi-Fi is in place in many hospitals, interference from cell phones and computers can block signals from monitoring equipment. Li-Fi solves both problems: lights are

not only allowed in operating rooms, but tend to be the most glaring (pun intended) fixtures in the room. As Haas mentions in his TED Talk, Li-Fi has 10,000 times the spectrum of Wi-Fi, so maybe we can, delegate red light to priority medical data.

**Li-Fi on Undersea Awesomeness:** Underwater ROVs, those favourite toys of treasure seekers and James Cameron, operate from large cables that supply their power and allow them to receive signals from their pilots above. ROVs work great, except when the tether isn't long enough to explore an area, or when it gets stuck on something. If their wires were cut and 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 referring findings periodically back to the surface, all the while obtaining their next batch of orders.

**Defence:** With established RF application it is not possible to communicate without proper instruments. As light is available everywhere, VLC communication is possible. Like RF jammer, VLC communication has no such barrier.

**Industrial:** RF communication is dangerous in areas with burnable materials like mines, petrochemical, power plants and petrol pumps. Here, Li-Fi can be used as safe alternative.

**Power Plants:** Wi-Fi and many other radiation types are bad for sensitive areas. Like those surrounding power plants. But power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars. Li-Fi could offer safe, abundant connectivity for all areas of these sensitive locations. Not only would this save money related to currently implemented solutions, but the draw on a power plant's own reserves could be lessened if they haven't yet converted to LED lighting.

## VI. ADVANTAGES AND DISADVANTAGES OF LI-FI

- High speed than Wi-Fi.
- •1000 times the frequency spectrum of radio.
- More secure because data cannot be intercepted without a clear line of sight.
- Prevents piggybacking.
- Eliminates neighbouring network interference.
- Unimpeded by radio interference.
- Does not create interference in sensitive electronics, making it better for use in environments like hospitals and aircraft.

### Drawbacks:

- It is a one-way connection, permitting download but no upload from the connected device.
- The light cannot get through walls and has a limited field of action.

## VII. CONCLUSION

By using Li-Fi in all the lights in and around a building, the technology could enable greater area of coverage than a single Wi-Fi router. If this 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 towards the cleaner, greener, safer and brighter future. In future, data for laptops, smart phones and tablets can be transmitted through light in room by using Li-Fi. In Li-Fi we don't need a license to set up a light bulb, as we set up a Wi-Fi network over radio waves. The increasing demand for higher bandwidths, faster and more secure data transmission as well as environmental and undoubtedly human friendly technology heralds the start of a major shift in wireless technology, a shift from RF to optical technologies. Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light. The visible light spectrum is larger than the radio spectrum. Since optical waves do not pass through walls this could be used as a means of secured communication.

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