

Light Fidelity (Li-Fi): A Wireless Technology

Sidra Azeem¹, Shamitha Jajula² and Sumera³

¹⁻³Stanley College of Engineering and Technology for Women, Hyderabad, Telangana, India.

Email: Sidraazeemmahi@gmail.com, jajulashamitha@gmail.com, mohdd.ubaidd@gmail.com

Abstract—Wireless communication is the need of the hour, there is a huge demand for improvement in the means of communication. The brewing crisis of the radio frequency (RF) spectrum demands the need for a system like light fidelity (Li-Fi) which relies on the aspect of visible light communications (VLC). Li-Fi technology offers a variety of effective solutions to problems faced in recent years. This technology utilizes data transmission by light, and the unique properties of the white light emitting diode (LED) lamp switching comes into play. In the proposed system we transmit an audio signal generated by a mobile phone. The signal is modulated and then transmitted by LEDs in form of a light signal which is read by the solar panel and the received signal is transformed into an electrical signal. The signal is demodulated and read by the speakers. Li-Fi is a fast, upcoming, and growing technology, it's a better alternative to Wi-Fi in wireless communication. In the present paper, the authors have focused on the pros of Li-Fi, its applications, and its fundamental working. Li-Fi is greener, safer, and more economically feasible in the future of communication.

Index Terms— Li-Fi, VLC (Visible Light Communication), LED, RF (Radio Frequency).

I. INTRODUCTION

One of the fundamentals of the wireless communication domain is transmission of information. when we consider transmission as an aspect we need to take into account its features like speed forms etc. The existing system for data transmission ie wired data transmission system has aged and slowed down. The introduction of wireless technology for data transmission has been proven to be revolutionary. Li-Fi (Light Fidelity) is one such technology which provides a faster channel for data transmission via light.

A. Goals and Features

The main aim of the research is to design a communication system to explain the working of Li-Fi (Light Fidelity) technology. In this system an audio signal is transmitted via LEDs.

B. Review of literature

Professor Harald Hass the original founder of data transmission through light devised the term Li-Fi. In October 2011 a union was formed between industries for the promotion of technology that would overcome the drawback of limited radio based wireless systems, thus in turn paving a way for Li-Fi technology.

In April 2014, a Russian company called Stins Coman developed a local network based on the idea of Li-Fi wireless, named Beam Caster. [4] describes how their current module transfers data at 1.25 GB/sec. but foresee boosting speeds up to 5 GB/sec.in the near future.

In [3] the author has indicated that the wireless networks have a promising future both as standalone systems and

as a component of the wider networking infrastructure, as seen by the rapid expansion of wireless systems combined with the widespread use of laptop and palmtop computers. The construction of reliable wireless networks that provide the performance required to enable future applications still faces numerous technical obstacles.

II. TECHNOLOGY WORKING

Li-Fi technology is said high speed communication network which functions to and fro that is bidirectional mobile communication network. It comprises of LEDs which form one of the wireless end of the network. The LEDs emit a series of streams of photons when electrical current is passed through it. LEDs feature of functioning as a semiconductor proves to be advantageous as the brightness of the light can be varies based on the high electric power applied. LED lights can be modulated at different rates before sending the signal using this property. At the other end of the system a detector is set up to receive the signal and to interpret the different variation of intensities in the light signal received as data.

The intensity of modulation enables the communication to be seamless as intensity of modulation isn't visible to the naked eye. This allows the individuals to use the Li-Fi enabled light communication.

III. WI-FI

One form of wireless technology is Wi-Fi. Wi-Fi is a local area networking (LAN) technology that is based on the IEEE and intended to give in-building broadband coverage. Current Wi-Fi systems typically offer indoor coverage over a 100-foot radius and support a peak physical-layer transmission rate of 54 Mbps. For last-mile internet access in homes, workplaces, and public hotspot areas, Wi-Fi has taken over as the de facto norm. System coverage normally extends no more than 1,000 feet from the entry point.

NCR (National Cash Register) and AT&T (American Telephone and Telegraph) established the Wi-Fi in the Netherlands in 1991. We can exchange information between two or more devices utilising this technology. Wi-Fi was initially designed for mobile computing devices like laptops, but it is now extensively used for consumer electronics like televisions, DVD (Digital Video Disc) players, and digital cameras as well as for mobile applications. Both client to client connections and access point to client connections should be options for communication over a Wi-Fi connection. Local area networks may function without cable and infrastructure thanks to Wi-Fi. It is a popular option for both residential and commercial networks.



Figure 1. Wi-Fi technology

C. Advantages Of WI-FI

- wires and hardware inconveniences will be eliminated.
- Setting up and configuring Wi-Fi is simpler than running cables.
- It is 100 percent secure and won't disrupt any networks.
- Hot spots are another way for us to access the internet.
- wireless broadband access is possible

D. Disadvantages of WI-FI

- Data transmission is sensitive to some restrictions; long distance transmissions aren't possible.
- Wi-Fi emits radiation that could be harmful to human health.
- Wi-Fi connection is comparatively costlier than traditional connection.

IV. LI-FI

A unique wireless communication technique called Li-Fi is appropriate for transmitting data via LEDs for illumination. Instead of using the RF range of electromagnetic spectrum, it makes use of the visible spectrum. Li-Fi technology combines wavelengths of 1 mm to 10 nm and frequencies of 300 GHz to 30 PHz. There are 100 times more electromagnetic waves than radio waves in this range.

Li-Fi is not just a technology; it also serves as the foundation for all future capabilities as services, applications, and end users.

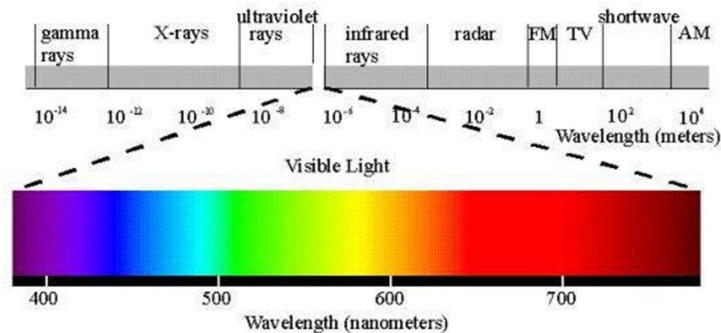


Figure 2. Location of visible light and RF at electromagnetic spectrum

In the Technology Entertainment Design (TED) global talk on Li-Fi, Professor Harald Hass, the inventor of Li-Fi technology, states: "At the heart of the technology is a new generation of high brightness LEDs," adding: "Very plainly, if the LED is on, you transmit a digital 1, and if it's off, you transmit a 0. They can be switched on and off very quickly, which provides nice opportunities for the data that's transmitted".

By altering the pace at which the LEDs flicker on and off to produce different strings of 1s and 0s, it is feasible to encode data in the light. The idea of data transmission utilizing light is seen in the figure below. Additionally, more advanced techniques could significantly boost Li-Fi data rates by using an array of LEDs, where each LED transmits a different data burst to provide parallel data transmission. The LED intensity is modulated so rapidly that the output appears constant to the human eye. Other concepts include altering the light frequency to encrypt a new data channel by combining red, green, and blue LEDs.



Figure 3. The idea of data transmission using light

E. Comparison between Li-Fi and Wi-Fi

Li-Fi is term that describes visible light communication (VLC) technology that is used for high speed wireless communication. Contrary Wi-Fi is employed regularly in day to day general wireless coverage for an area of building. Li-fi is suitable for high density wireless data coverage that is confined to an area and eliminates radio interference, wire hardware issues etc. But in conclusion the two technologies can be said to be complimentary to each other.

F. Li-fi Applications

- Traffic control: Li-Fi can assist in improving traffic management and decreasing the number of accidents. To control street traffic, traffic lights can interact with each other and with vehicles
- Airways: To avoid mobile phone signals interfering with aircraft navigation and control signals, smart phones must be turned off inside of aircraft. In [5] the author mentions how Li-Fi doesn't interfere with RF, it can be used in airplanes without risk. We could also use the lights above the seats in the plane as hotspot.

- Disaster management: In times of disaster, such as earthquakes or hurricanes, Li-Fi can be used as a powerful means of communication. For instance, locations like subway stations and tunnels, which are typically dead zones for most emergency communications, don't cause harm for Li-Fi, so it can be used there as an emergency communication.
- Medical applications: One of Li-Fi's most significant advantages is that it can be utilized in hospitals and other facilities where RF transmissions that could damage medical equipment are prohibited. For instance, Wi-Fi use is prohibited in OTs (Operation Theatres) due to radiation safety concerns because it interferes with signals from monitoring equipment. Consequently, it might be detrimental to the patient's health.
- subaquatic communications: Due to the significant signal absorption that occurs in water, using RF signals is not feasible. Li-Fi provides a short-range communication solution. With the help of their headlamps, submarines could communicate with one another, interpret data on their own, and periodically send their discoveries back to the surface in underwater remotely operated vehicles (ROV).



Figure 3. The idea of data transmission

V. DESIGN APPROACH

This segment will display and discuss the specifications required for the construction and working of the system, its components.

G. Functional Block Diagram

Here Fig. 3 demonstrates the Functional Block Diagram of the system.

Transmitter side : The transmitter side consists of a signal source and a circuit which employs the LEDs.

Receiver side: The receiver side contains a circuit which receives the signal, here we use a solar panel and a device which hold the ability to interpret the received output.

H. Components

Each component hold its own significance and performs a certain function in the given system. The components are listen below:

- Power Source
Power source is required by both the transmitter and the receiver side. Every components requirement for power varies accordingly. The transmitter uses the same power source but converts that power into required divisions for different components. The output device that is the speaker uses a 120V AC output, here we connect it directly to AC power.
- Signal Source

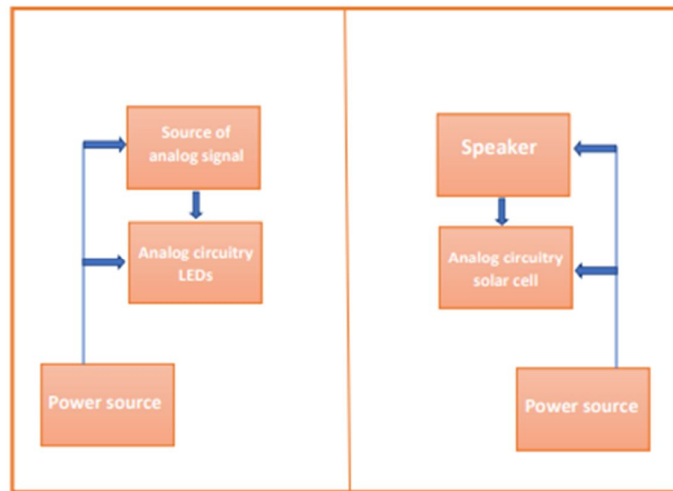


Figure 4. Functional Block Diagram

The signal used here is an audio signal. This signal will be introduced into the system through a cell phone or any other devices which can act as signal sources. The signal is then sent to the circuit. The receiver needs to be able to analyse the given signal and produce the required output in form of sound.

- **3.5mm audio jack**
Input from the audio source or cell phone gets converted from digital to analog signal by the 3.5mm audio jack. The structure of the audio jack is such that it is divided into 3 parts. Those are right left and ground. The left and right arts are connected to the resistor which further connects to the transistor. The ground part is connected to the negative of the power supply and to the transistor's emitter.
- **Resistors**
The function of the resistor is to limit or resist the flow of current flow, for the division of voltages, to adjust signal levels and bias active elements.
- **Transistor (BJT)**
Here the transistor behaves like switch. The transistor connects the input signal source to the light emitting source that are the LED. The LEDs would receive more current and power in this manner. As a result, LEDs would become brighter and achieve greater transmitting distance.
- **LEDs**
The LEDs in this system are employed for imparting the sensory data from the transmitter to the receiver. Five red LEDs with the following standards are used in this circuit: 620–625 nm wavelength, 2000–3000 mcd luminance, 30° viewing angle, 2V forward voltage, and 20mA forward current. They used a transistor to control the conversion of the audio signal into light, which was then used to transfer data to the receiver. In reference to [2] which states that small variation of the density of LED light is transformed by the “receiver” to electrical signal. The signal is then transformed back to binary data stream that recognized as sound wave.
- **Solar cell**
The solar cell on the receiver side would collect the transmitted light from the LEDs (3-6V DC). This signal would then be converted to an electrical signal by the solar cell. The solar cell receives irradiance with the best potential power density when the LEDs' transmitted light is perpendicular to the solar cell.
- **Speaker (Computer speaker)**
The computer speaker, the final part on the receiver side, is connected to the solar cell to alter the electrical signal into an audio signal. Despite being directly linked to the AC power, this speaker includes an inbuilt amplifier and is output to a wall with a 120V AC output.

VI. RESULT

First, the audio signals that had been received at the receiver's end were evaluated. Because of the other light sources around the system, the signal was initially detected by the receiver as a sound with a significant amount

of disruption. The distance of 11 cm between the transmitter and the receiver produced the loudest and clearest sound, and the receiver could pick up the signal for almost 60 cm then after. The apparatus also may transmit and receive signals up to a distance of 1 metre in the experiment when there are less light sources around.

VII. CONCLUSIONS

Many wireless technologies are developing and growing as a result of the rise in high-speed data consumption, with Li-Fi holding the most promise. It is a technology that works well, quickly, and economically. Even the Indian IT ministry put life to the test in a collaborative project with IIT Madras and Philips Lighting. If Wi-Fi and many other broadband networks are replaced by Li-Fi technology, daily life will undergo a significant transformation. High-speed data transfer is this technology's main obstacle, yet new and developing technology is advancing recently and may someday explain the world's many mysteries.

FUTURE SCOPE

Li-fi technology offers a lot of potential applications since it might result in communications that are cleaner, greener, safer, and have a bright future and environment. People will utilise technology more frequently if it gets developed and well-liked, and it may then play a significant role in the mob's ability to communicate more quickly. Li-Fi has the potential to eventually replace current unguided, quick, and secure data transmission technology. According to Neena Pahuja, director general of the Education and Research Network (ERNET), an independent scientific institution under the IT ministry, "Li-Fi might be employed in India's forthcoming Smart Cities — where IT will be the key infrastructure." Li-Fi could function as an internet hotspot in traffic systems.

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