

A Major Leap for Transmission & Communication Technology: Li-Fi

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ABSTRACT

The technology provides transmission of data through an LED light bulb using illumination phenomenon with a data transfer rate higher than persistence of vision. The technology uses light as transmission media in order to achieve high data transfer rates with increased spectrum range at lowest possible cost. System design proposed in this project uses 8051 microcontroller programmed in fashion which converts the data into binary code which is transmitted through LEDs. Light dependent resistor (LDR) is used at the receiving end which senses the voltage at which LEDs are flickering and data is generated in the form of binary code i.e. 1's and 0's according to ON and OFF state of LED which is then decoded using microcontroller. Implementation of this system will increase data transmission rate than that of Wi-Fi, it does not required to add parity bit which reduces errors and increases accuracy of the system, and since visible light communication is used, gives greater frequency range (up to 750 THz) for data transmission.

Keywords— Li-Fi, LED, Light Dependent Resistor, visible lightcommunication, Wi-Fi, wireless communication

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I. INTRODUCTION

The need for data round the globe is ever increasing. If due to congestion in network or bandwidth issues, data transfer is not possible. Li-Fi technology is an emerging technology which solves all the issues related to data transfer. The technology was introduced by a German physicist, Harald Haas, in his TED global talk on Visible Light Communication. According to Haas, this technology can be used to produce data rates higher than 10 megabits per second which is much faster than our usual broadband connection. This light was referred to D light by him. As Li-Fi technology makes use of the visible spectrum of light which is abundantly available there will be no complications regarding it's bandwidth as well as the radiation concerns which occur due to prevailing technologies.

The persistence of vision plays an important role in the transmission of the signal via Li-Fi. In this technology the data is first translated into binary format then sent via LED bulb. The data rate to be achieved should be such that it should overcome persistence of vision. The transmitted data is then sensed by either of the photo sensing circuits which then converted back into it's fundamental form

II. PRINCIPLE OF LI-FI COMMUNICATION

This Li-Fi technology follows the concept of data through illumination which means sending data through an LED light bulb that varies in intensity faster than the human eye can follow in the form of 1's and 0's for transfer of data. The flickering of LEDs to transmit data wirelessly is referred as visible light communication (VLC).

(A) Visible Light Communication

Li-Fi is optical version of Wi-Fi that uses visible light communication for data transfer using visible light between 400 THz(780 nm) and 800 THz(375nm). The presumption behind VLC is because lightning is everywhere; communications can ride along for nearly free. One of the biggest attractions of VLC is the energy saving of LED technology, which makes visible light LEDs ideal for ubiquitous data transmitter.

Guided by the progress of LED technology, visible light communication is deriving attention in research and technology field. The VLC Consortium (VLCC) in Japan was the first institute to introduce this technology.

(B) Devices used in proposed Li-Fi System

1. LED lamp
2. LDR(Light Dependent Resistor)

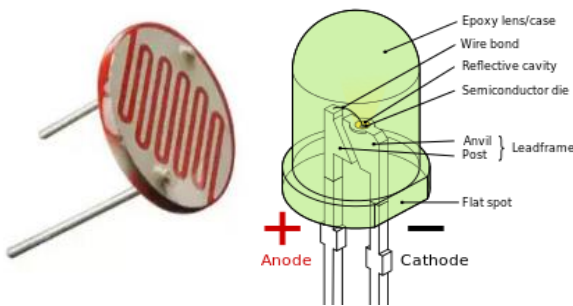


Fig 1: LDR

Fig 2:Light Emitting Diode

III. CONSTRUCTION AND WORKING OF THE PROPOSED LI-FI SYSTEM

The proposed system consists of microcontroller (8051), IC ULN, LCD display, array of LED and LDR, and array of resistors.

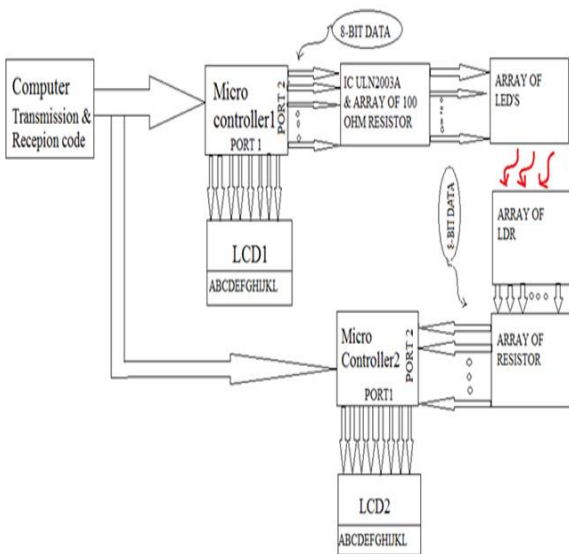


Fig 3: Block diagram of the System

In this system a code for transmission is fed to microcontroller 1 and is displayed on LCD1 (for user to view the data to be transmitted). Each letter or number transmitted is converted into 8-bit code (of 1's and 0's) by the controller (digital signal). This signal can't be used

directly to drive the LED's, as the array of LED's load the signal. Hence ULN2003A is used to avoid the loading effect [4].

An array of (8) 100 ohm resistor along with 8 channels of ULN is used as driver circuit for LED's. The LED's turn on and off depending on the input given and the corresponding signal is captured by array of (8) LDR's. This signal is then fed to microcontroller 2 via an array of (8) 330 ohm resistors. By using the reception code and input from LDR's the data is received and displayed on LCD 2. Thus the data transmission and reception is achieved.

IV. RESULT ANALYSIS

The following results were obtained after implementation of our system.

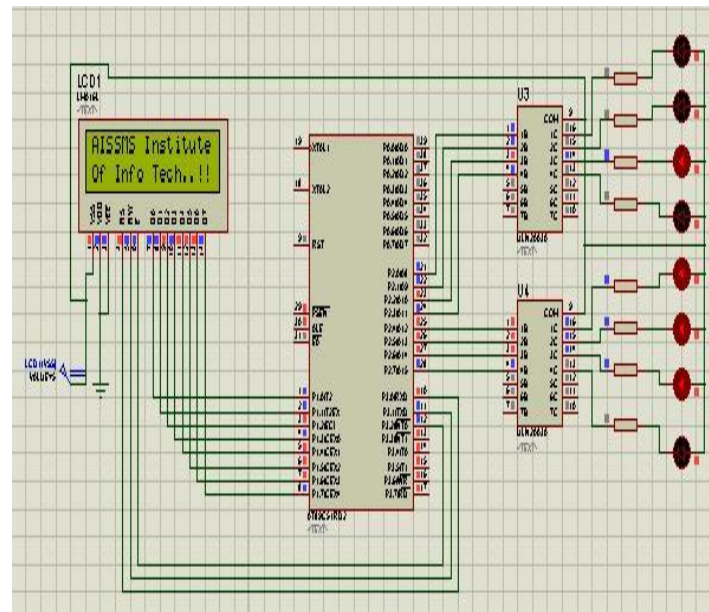


Fig 4: Transmission Circuit

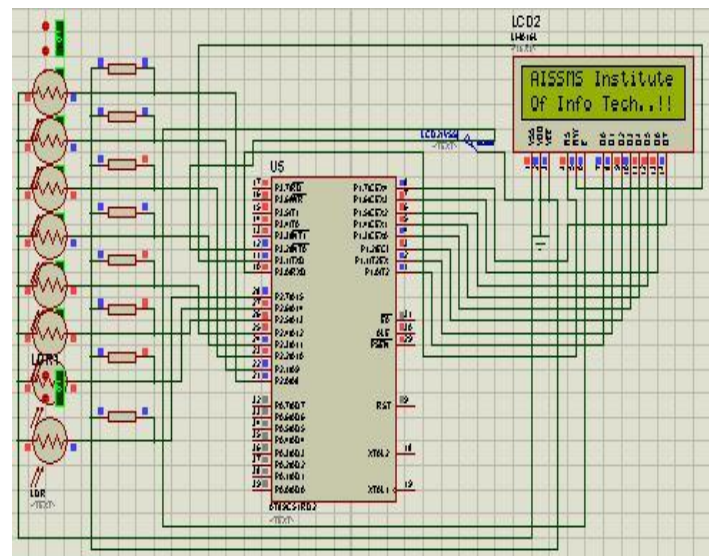


Fig 5:Reception Circuit

V. COMPARISON BETWEEN LI-FI AND WI-FI

Li-Fi technology gained it's nomenclature from Wi-Fi technology. As Wi-Fi technology uses the medium of radio waves to transfer data (packets, images, videos, documents

etc.) , in the same way Li-Fi technology uses medium of visible light to transfer data. Being a bi-directional technology, Li-Fi is 100 times faster in comparison to Wi-Fi and it can reach speed of up to 224 gigabits per second. One of the peculiar benefits of the Li-Fi technology is that it is a viable solution to the limitations of the RF- bandwidth, which is a power- packed solution which includes a standardization process which had made considerable advancements in the industry.

The IEEE standard for Wi-Fi is 802.11n whereas for Li-Fi it is 802.15.7 [1,6]. The transfer speeds of various technologies are mentioned below:

Technology	Max Speed
Wi-Fi(IEEE--802.11n)	150 Mbps
Bluetooth(IEEE--802.15.1)	3 Mbps
Li-Fi(IEEE-- 802.15.7)	>1 Gbps

VI. PROBLEMS IN WI-FI

The following are basic issues faced while using radio waves:

- Capacity:** Massive amount of wireless data is transmitted through radio waves which are limited and expensive. The biggest issue with radio waves is currently about the "Spectrum Crisis" in which the radio wave frequency spectrum is running out of bandwidths(3G, 4G,5G and others).
- Efficiency:** The issue with radio waves is that they have to be steadily regenerated if they have to travel a long distance. There are 1.4 million cellular base stations that dissipate large amount of energy. Most of the energy is used for cooling down the base stations instead of transmission. Consequently efficiency of these base stations is only 5%.
- Availability:** Availability of radio waves is a major concern. It is not advisable to use mobile phones in aero planes and at places like chemical plants because of their interfering and inflammable nature.
- Security:** Radio waves can infiltrate through walls. They can be probably intercepted. If someone has the right software(knowledge) and bad intentions, they may misuse it. This is the biggest security concern related to radio waves.

The following table is the result of a study conducted in Copenhagen, Denmark while testing scope of Li-Fi under lab conditions and results when compared to Wi-Fi [3]:

Parameter	Li-Fi	Wi-Fi
Speed	***	***
Range	*	**
Data density	***	*
Security	***	**
Reliability	**	**
Power available	***	*
Transmit/receive power	***	**
Ecological impact	*	**
Device-to-device connectivity	***	***
Obstacle interference	***	*
Bill of materials	***	**
Market maturity	*	***

* low ** medium *** high

Fig 6: Comparison between Li-Fi and Wi-Fi

VII. ADVANTAGES OF LI-FI TECHNOLOGY

Li-Fi technology is based on LEDs and other similar light sources for transfer of data. The transfer is possible using all sources of light, no matter which art of spectrum is harnessed. Light used in Li-Fi can also belong to invisible part of the spectrum. Also because of huge amount of available bandwidth, the speed of communication is very high and enormous amount of data(movies, videos, games) can be downloaded within seconds.

Also, Li-Fi removes the limitations that have been put on the user by the Wi-Fi mentioned as follows:

- Capacity:** Light has 10000 times wider bandwidth than radio waves [1]. So, Li-Fi has got better capacity and also the equipment's are already available.
- Efficiency:** Data transmission using Li-Fi is very cheap. LED lights consume less energy and are highly efficient.
- Availability:** There are billions of light bulbs worldwide; they just need to be replaced with LEDs for proper transmission of data.
- Security:** Light waves do not go through walls. So, they can't be intercepted and misused.

VII. CHALLENGES

There were challenges faced while implementing our Li-Fi system. The surroundings had to be enclosed and free from other light interferences. The ambient lights also had to be eliminated for the system to be working. The position of the receiver and transmitter (bulbs) had to be properly adjusted i.e. in direct line of sight [1].

VIII. LIMITATIONS

Apart from many advantages over Wi-Fi, Li-Fi technology is facing some challenges. The limitation of this technology is that light cannot penetrate through walls and other forms of light attenuate the intensity of light emitted out by the system. Also the user has to be in direct line of sight to avail the use of Li-Fi.

IX. APPLICATIONS

There are voluminous applications of this technology, from providing internet through street lamps to use LEDs to guide vehicles using their headlights. Applications of Li-Fi can extend in domains where Wi-Fi technology lacks its presence like medical technology, power plants and various other areas. Since Li-Fi uses light as a medium, so it can be safely used in aircrafts and power plants where Wi-Fi is forbidden because of its interfering and inflammable nature of radio waves [6]. In the future, every street lamp can be used to access the internet with ease.

Some of the future applications of Li-Fi are as follows:

- 1) **Education Systems:** Li-Fi is the latest technology which provides fastest speed of internet access [1,3,6]. So it can compensate for Wi-Fi at educational institutions and at companies so that all users can make use of Li-Fi with the same speed in a particular area.
- 2) **Medical Applications:** Operation theatres can be the perfect locations for Li-Fi as Wi-Fi is not permitted in hospitals due to their radiations. To overcome this issue and to make operation theatres tech savvy Li-Fi can be used to access internet and control medical reports. This can also help in easing surgeries and other automated processes.
- 3) **Cheaper internet in Aircrafts:** The Wi-Fi equipment is not used in aircrafts because of its interfering nature with navigational system of the pilots. Li-Fi can be easily used for data transmission in aircrafts and can be used as an overhead bulb for internet access.

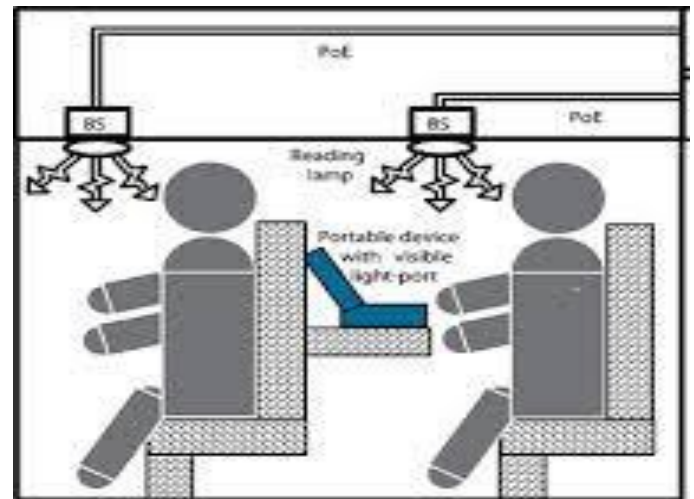


Fig 7: Li-Fi application in aero planes

- 4) **Underwater applications:** Underwater ROV's (Remotely operated vehicle), submarines and other related systems are unable to access the internet under the sea [1]. Hence, Li-Fi is an efficient solution for data transfer underwater. If the equipment for communication inside the submarines were replaced by a high power lamp then the process of data transfer is possible underwater.
- 5) **Smarter power plants:** The power plants and chemical plants are spread over a huge area and transfer of data in the plant from one department to another takes a considerable amount of time. Also because of Wi-Fi's (radio waves) inflammable nature it is not suitable to deploy it in a power/chemical plant. Here Li-Fi technology proves to be a boon as it is a safe and economical option.
- 6) **Traffic Management:** If the traffic signals are installed with Li-Fi equipment connected to the timer it can ease traffic management by counting number of vehicle according to headlights and setting the timer of the signal according to the amount of vehicles at the signal. Also the accident numbers can be decreased using Li-Fi technology.

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