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Li-Fi (LED Based Data Transfer)

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***Abstract* —** This paper states Li-Fi is an LED based alternative that uses visible light spectrum instead of radio frequency spectrum. Li-Fi not only eliminates the problem of radio frequency congestion but it also helps in transferring data in places where radio frequency communication fails.

***Keywords* —** *Li-Fi, Visible Light, LED, Radio Frequency, Wi-Fi*

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I. Introduction

Light Fidelity (Li-Fi) is a data transfer technique that uses light. Light is analogous not only to illumination but also speed. Thus Li-Fi provides very high data rates. Besides this Li-Fi is also very secure since light cannot pass through walls.

Li-Fi uses the visible light spectrum. Thus it is also known as the visible light communication. Visible light is unregulated unlike radio frequency spectrum. Hence it is cost effective. Besides this the visible light spectrum has large bandwidth that can be used. Hence visible light communication solves the problem of radio frequency congestion. Thus excess capacity demands of cellular data can be matched using Li-Fi. This is especially effective on downlink communication where bottlenecks can occur.

Li-Fi provides usage in many internet content consumption applications like audio and video downloads, live streaming etc. These applications demand larger downlink bandwidth but they need minimum downlink requirement. In this way majority of internet traffic is offloaded from existing radio frequency communication to the visible light communication (Li-Fi). This helps in decongestion of radio frequency spectrum thereby extending cellular and Wi-Fi capacities.

To realize a future society that can share information at superfast speeds, new system for the transmission, reception and processing of variety of signal and information are gaining importance. The opportunity to send data usefully in this manner has largely arisen because of the widespread use of LED light bulbs. LEDs are semiconductor devices similar to silicon chips.

Consequently, we can switch these bulbs at very high speeds that were not possible with older light bulb technologies such as fluorescent and incandescent lamps. The rapid adoption of LED light bulbs has created a massive opportunity for visible light communication. The problem of congestion of the radio spectrum utilised by Wi-Fi and cellular radio systems is also helping to create an increased interest various areas of usage to enhance the performance of existing system. Moreover, visible light or the LED lights pose no threat to the human life proving extremely safe as it inhibits the harmful radiations often leading to fatal mutations.

Artificially created and naturally available light is abundant and its lies in the frequency range of 400-790THZ also its wavelength range of 380-750nm. Considering the tremendous speed of light, it is a useful tool for high speed requirements of communication especially over large distances.

Li-Fi uses the unregulated and not so popular band of the electromagnetic spectrum, that is the Visible Light Spectrum. This spectrum was thought to be useful only for optical purposes until Li-Fi was introduced. Light is such a common part of our lives. Besides this the visible light spectrum 10,000 times wider than the radio frequency spectrum. The count of LED bulbs is increasing day by day. These LED bulbs can not only be used as a light source but they can also be put to use as a Li-Fi hotspot. Researchers have achieved speeds of upto 224 Gbps at The University of Oxford. This is a way lot quicker than the 100 Gbps that was achieved using fibre optic communication as well as extremely quicker than the 600 Mbps speed achieved using Wi-Fi.

II. Working:

LED and photodiode are the major components of Li-Fi circuitry. AtMega 16 micro controller is used in the circuit for mode selection between pc and sensor and to provide coding of the serial data signal into voltage input to the led array. Li-Fi is typically implemented using white LED light bulbs at the downlink transmitter. LED's are normally used for illumination only by applying a constant current. However, by rapid and continuous variations of the current, its output can be flickered at very high speeds.This very property of LED's is used in Li-Fi setup. The basic principle of operation is very simple, if the LED is on, you transmit a digital 1, if it's off you transmit a 0.

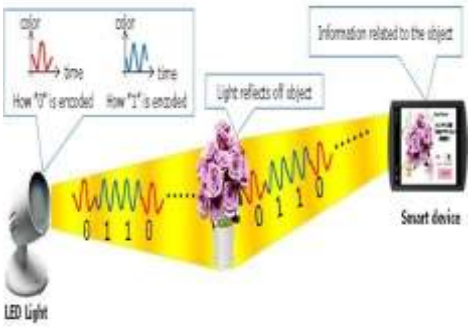

Figure 1. Encoding of 0's and 1's

The LEDs can be switched on and off very quickly, which gives nice opportunities for transmitting data. Hence all that is required is some LEDs and a controller that code data into those LEDs. All one has to do is to vary the rate at which the LED's flicker depending upon the data we want to encode. We have designed a prototype LIFI system to transfer data such as text, image, video. The system consists of a transmitter and a receiver.

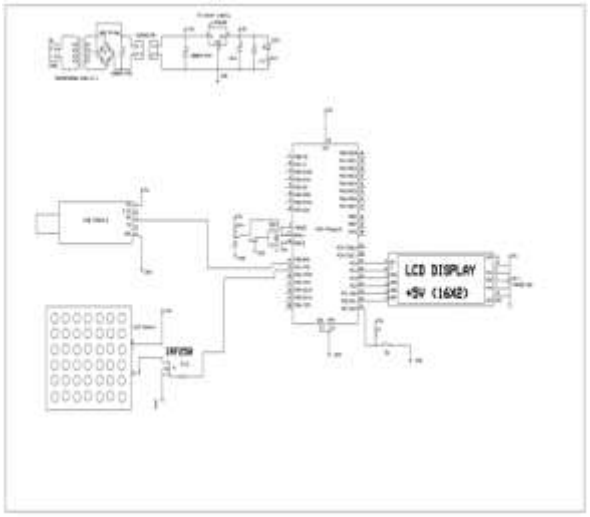

Figure 2. Circuit diagram of transmitter

At the transmitting end, data from the pc is sent to the receiver(Rx) terminal of the microcontroller via a USB cable. The microcontroller has an inbuilt ADC. A 16x2 LCD is connected to port C of the microcontroller so as to provide information about the status and health of the system. Sensors are connected to the port A, a gas sensor MQ6 is used. A thermistor is used to sense the temperature. Port B is connected with a switch for mode selection between pc and sensor input.

The microcontroller processes the signal and then the signal is amplified using a n-channel MOSFET. The output of this amplifier serves as an input to the LED array. When the LED is on, the transmitted data is 1 and when the LED is off the transmitting data is off.

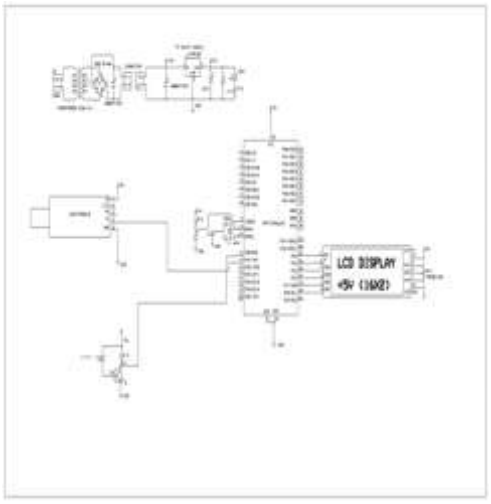

Figure 3. Circuit diagram of receiver

The receiving terminal also comprises of similar hardware except for the photo detector to track the data sent through the light from the led system. It consists of the phototransistor as a light sensor, whose output is fed to a comparator built using low power OP-AMP. The non-inverting terminal has a phase delay circuit. The comparator circuit makes the DATA IN into binary compatible levels. Even though the amount of light falling on the phototransistor varies, the comparator ensures that it is modified to a correct binary level which can be processed by the microcontroller. At the receiving terminal, the output from the transmitter is first amplified using a n-channel MOSFET. The output of the amplifier is given to the receiving terminal (Rx) of the microcontroller. A 16x2 LCD is attached even in the microcontroller at the receiving side. This LCD array is used to provide information regarding the status and system health. The microcontroller processes the signal through its transmitting terminal (Tx) is passed to the receiving pc using a USB cable.

X-CTU is a terminal program that is used to provide an interface between the user(laptop) and the circuit.

FileSendComm is the software that is used to transfer data such as image files, pdf's, audio and video files etc. from between the laptops. Baud rates as high as 115200 is achieved using this circuitry.

III. Applications

A. Hospitals and healthcare

Wi-Fi cannot be used in hospitals since it causes electromagnetic interference there by tampering the readings and the working of other medical instruments and devices. Since Li-Fi does not cause any electromagnetic interference it can be used in hospitals

B. Smart Street Lamps

Street lamps with LED bulbs can not only be used as a source of light but also as a hotspot. Thus easy access to internet and internet for all that too at very fast speed can become a reality in the near future using Li-Fi.

C. Vehiular Communication

The tail lamps, head lamps, signals, signage etc. use LED's. This can be used by vehicles for vehicle to vehicle communication as well as vehicle to roadside communication, thereby helping in traffic management and road safety.

D. Aviation

Li-Fi can be used in aeroplanes to reduce its weight and cabling. Besides this Li-Fi will also not emit electromagnetic spectrum to interfere with other devices in the cockpit.

E. Underwater Communication

At the sea bed, radio frequency communication fails i.e Wi-Fi cannot be used there. Also acoustic waves have very small spectrum. Thus Li-Fi can be used in underwater communication.

F. Hazardous environment

Li-Fi can be used in hazardous environments such as mines and petrochemical plants as an alternative to other radio

frequency communication techniques that cause electromagnetic interference.

G. Mobile connectivity

Li-Fi can be used to connect smart phones, tablets, laptops and other mobile devices to communicate with each other for data sharing.

IV. Advantages:

- Li-Fi solves the problem of radio frequency congestion.
- Visible light has a very large spectrum.
- Visible light is safe for humans,
- Very high data rates.
- Since light cannot penetrate walls Li-Fi is secure. It provides better security as compared to Wi-Fi.
- Li-Fi can be used in places where radio frequency communication fails.
- Li-Fi has lower cost of implementation and lower cost of maintainance.
- LED is smaller in size than the conventional antenna.

V. Disadvantages

- 1.Li-Fi requires line of sight.
- 2.If the intensity of an external source of illumination such as sun is greater than the intensity of the transmitting LED array then the data to be transmitted is washed out.
- 3.The receiver cannot transmit back or provide feedback to the transmitter.

VI. Conclusion:

The possibilities are numerous to look for and can be explored further. This project gives a new dimension to the very popular LED's as speed data transmitters. It can be viewed as a replacement to RF communication for short ranges to some extent. VLC has no health hazards associated with it. If his 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 toward the cleaner, greener, safer and brighter future. As a growing number of people and their many devices access wireless internet, the airwaves are becoming increasingly clogged, making it more and more difficult to get a reliable, high-speed signal. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals.

The excess radio frequency spectrum demands of cellular networks and Wi-Fi can be met by using Li-Fi. Besides this the visible light spectrum is unregulated and vast. So Li-Fi not only solves the problem of radio frequency congestion but it also is very cheap as compared to radio frequency communication. Li-Fi has incredible data rates that can be put into use as a solution in many real time applications.

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