Light Fidelity Enabled Data Transmission with Automation and Biomedical Application

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Abstract: Li-Fi stands for Light Fidelity .Li-Fi technology provides transmission of data through illumination by sending data through LED that varies in intensity faster than the human eye can follow. This paper focus on developing a Li-Fi based system and analyze its performance with respect to existing technology. The heart of this technology is a new generation of high brightness LEDs. The paper discusses about an apparatus consisting of a transmitter which includes a light source and the receiver circuit which receives the data transmitted via light waves. The same system can be employed in industries making industrial automation using the existing light source a reality. A biomedical sensor is also introduced herewith which helps in diagnosis of a patient's medical conditions and is quickly made available to all the emergency points through light.
Keywords: FLED, Li-Fi, VLC, Wi-Fi

I. Introduction

Li-Fi is a new exemplar for photosensitive wireless technology to provide unprecedented connectivity within a localized data centric environment. There has been a complete shift in wireless technology due to increase demand for faster and more secure and protected data transmission. Li-Fi is such a free band which is license free that is why it is less at cost than Wi-Fi. With the use of special intonation using a distinctive signal processing technology thousands of streams of data can be transferred simultaneously at higher speed. Li- Fi is useful in aircraft because the lights present above head can be used for data transmission. It is useful in controlling traffic at traffic signals as it communicates with LED lights of cars. Where there is difficult to amateur optical fibers LI-Fi is used. The new Li-Fi technology can be well managed very easily and it is pretty simple. Professor Harald Haas and his research team first developed the modern concept of Li-Fi at the University of Edinburgh, ironically in labs within the Alexander Graham Bell Building (Bell was born in Edinburgh and attended the University). Li-Fi was developed as a solution to the growing radio spectrum congestion problems. Haas demonstrated the technology by streaming live video for the first time at TED Global in July 2011, and the term 'Li-Fi' was coined by him during this talk. The company pure VLC was created in 2012 in order to commercialize Li-Fi.

Li-Fi is transmission of data through illumination by taking the fiber out of fiber optics by sending data through a LED light bulb that varies in intensity faster than the human eye can follow (as shown in Fig. 1). Li-Fi is the term some have used to label the fast and cheap wireless-communication system. Researchers at the Heinrich Hertz Institute in Berlin, German, have reached data rates of over 500 megabytes per second using a standard white-light LED. The technology was demonstrated at the 2012 Consumer Electronics Show in Las Vegas using a pair of Casio smart phones to exchange data using light of varying intensity given off from their screens, detectable at a distance of up to ten metres [1].

In October 2011 a number of companies and industry groups formed the Li-Fi Consortium, to promote high-speed optical wireless systems and to overcome the limited amount of radio based wireless spectrum available by exploiting a completely different part of the electromagnetic spectrum. The consortium believes it is possible to achieve more than 10 Gbps, theoretically allowing a high-definition film to be downloaded in 30 seconds[2].

In this paper, section II give details of existing wireless communication systems. Section III is about the proposed system, that is Li-Fi communication technique and the section IV elaborate data transmission system using Li-Fi. In industries, the electric load is controlled by a centralized system from which the control signals are sent via Li-Fi is explained in section V. Also, we introduce a biomedical application in section VI about a biosensor which determines pressure and rate of heartbeat accurately. Here also, the result will be displayed using the Li-Fi technology.

II. Existing System

On a daily basis, people use one type or another of wireless transmissions. Cellular phones, remote controls, stereos and televisions all use one of the three wireless transmissions: radio, microwave and infrared. Factors such as distance, speed and privacy dictate which type of wireless transmission a device requires. The

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2.1 Radio Transmission

Radio frequencies (RF) are radio signals used by many media outlets including TV and radio broadcasting, wireless local loop, amateur radio and mobile communications, including cordless telephones. These radio waves are part of the electrometric spectrum and fall into many different bands including FM, AM and VHF. An antenna radiates the signals that produce current feeds back and forth to the different points. The frequencies range from around 3 hertz up to 300 gigahertz. Remote controls and cordless phones use unregulated frequencies that include 902 to 928 megahertz, 5.72 to 5.85 gigahertz and 2.4 gigahertz. The Federal Communications Commission regulates the assignment of radio frequencies ranging from 10 kilohertz to 1 gigahertz.

2.2 Microwave Transmission

Microwave transmission waves represent the upper level of the radio frequency spectrum, usually above 1 gigahertz. The microwave spectrum has more bandwidth than most other frequencies, this is why it is and has been used in many applications including wireless LAN (Wi-Fi), wireless PAN (Bluetooth), wireless WAN (2G/3G cellular networks) broadband wireless access or wireless MAN (WiMAX), radar and satellite communications. There are two types of microwave transmissions, terrestrial and satellite. Terrestrial uses microwave towers within a line of sight of each other to link networks together. The frequencies range from 4 to 6 gigahertz or 21 to 23 gigahertz. Satellite transmissions use a satellite that orbits the earth in a fixed position. The satellite can share signals with a station on the ground. Satellite frequencies range from 11 to 14 gigahertz.

2.3 Infrared Transmission

Infrared light has a longer wavelength than visible light yet shorter than radio waves. The frequency for infrared light usually spans from 300 gigahertz to 400 terahertz. The use of infrared waves figures prominently in the use of night vision technology and remote controls for televisions. Using the standards of the Infrared Data Association, these waves can play a role in a larger range of applications, such as dial-up networking, synchronization, file transfer and payment. The two types of infrared transmissions are point-to-point and broadcast. Point-to-point transmissions, limited to the line of sight, use frequencies ranging from 100 gigahertz to 1,000 terahertz. Broadcast transmissions disperse so that more than one unit can receive the transmission. Their frequency range is 100 gigahertz to 1,000 terahertz [2].

Among them, Wi-Fi (Wireless LAN) is the most advanced form for internet access to a localized environment. To connect to a Wi-Fi LAN, a computer has to be equipped with a wireless network interface controller. The combination of computer and interface controller is called a station. All stations share a single radio frequency communication channel. Transmissions on this channel are received by all stations within range. The hardware does not signal the user that the transmission was delivered and is therefore called a best-effort delivery mechanism. A carrier wave is used to transmit the data in packets, referred to as "Ethernet frames". Each station is constantly tuned in on the radio frequency communication channel to pick up available transmissions [3].

Fig.1 Illustration of data transmission through LED

These can connect to a network resource such as the Internet via a wireless network access point. Such an access point (or hotspot) has a range of about 20 meters (66 feet) indoors and a greater range outdoors. Hotspot coverage can comprise an area as small as a single room with walls that block radio waves, or as large as many square kilometres achieved by using multiple overlapping access points.

III.   Proposed System

A new generation of high brightness light-emitting diodes forms the core part of light fidelity technology. Here, we are introducing FLED (Flash LED) LIGHTS. The logic is very simple. If the LED is on, a digital 1 is transmitted. If the LED is off, a digital 0 is transmitted. These high brightness LEDs can be switched on and off very quickly which gives use a very nice opportunities for transmitting data through light.

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 another. 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 colours, to obtain data rates in the range of hundreds of megabits per second. 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[4].

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'[5].

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.
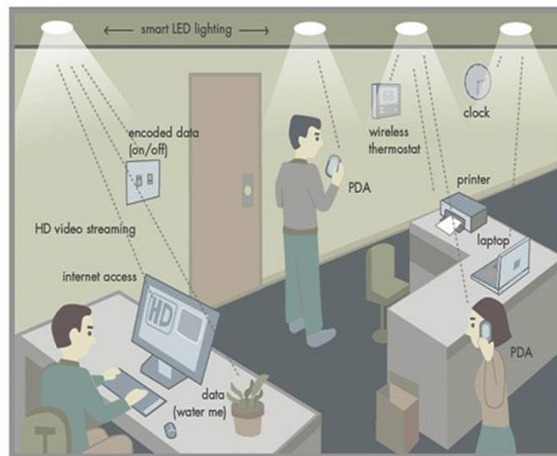

Fig.2 Future advancement of Li-Fi transmission system connecting devices in a room
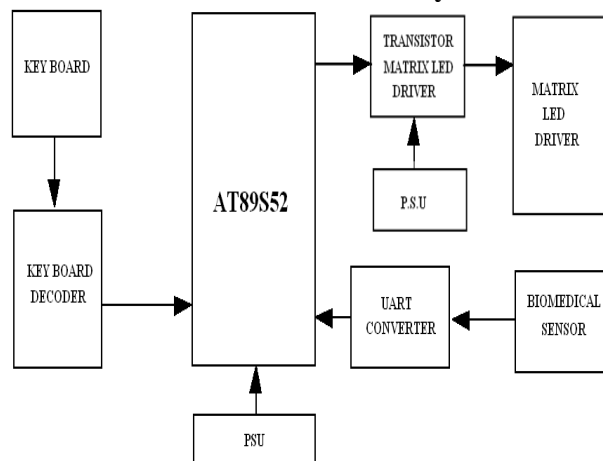
IV.   Data Transmission System

Fig.3 Li-Fi Transmitter section including data to be displayed, automation signal and biomedical sensor input

The working of the circuit in Fig 3 can be understood from the component details. The first part is a micro controller based circuit that accepts ASCII format code from a key board decoder and sends it through the serial transmit pin. Key board decoder is a circuit that accepts row and column addresses from a standard keyboard and

converts it to ASCII. The ASCII output is available as UART data at the output pin of the decoder. Following are the UART specifications of key board decoder. Start bit: NULL, Stop bit: 1, Parity bit Null, Data bits 8, and Baud rate is 9600[6].

The microcontroller output is given to the next section shown in Fig 5. The data is taken serially through a USB to UART converter cable which utilizes serial mode of communication. In simple words serial communication is the exchange of data between two devices serially i.e. through single or two wires. In our case serial communication is referred to as communication between microcontroller and computer or between microcontroller and microcontroller. Serial communication is done using RS-232 Protocol that is a standard.
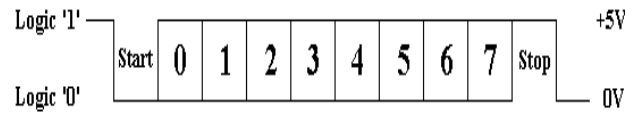

Fig.4 TTL/CMOS Serial Logic Waveform

The diagram above shows the expected waveform from the UART when using the common 8N1 format. 8N1 signifies 8 Data bits, No Parity and 1 Stop Bit. The RS-232 line, when idle is in the Mark State (Logic 1). A transmission starts with a start bit which is (Logic 0). Then each bit is sent down the line, one at a time. The LSB (Least Significant Bit) is sent first. A Stop Bit (Logic 1) is then appended to the signal to make up the transmission. The data sent using this method, is said to be framed. Fig 4 is the data is framed between a Start and Stop Bit [7] .
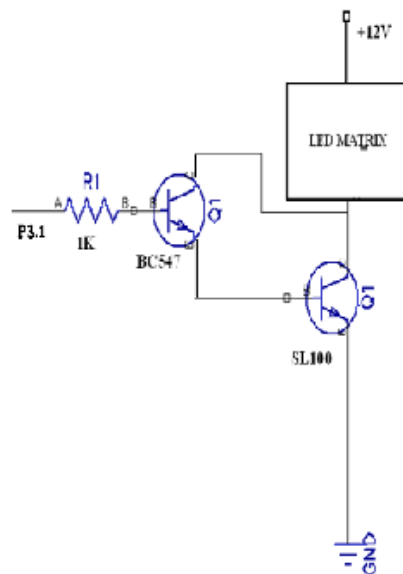
Fig.5 Matrix LED driver circuit

The serial data from the UART is provided as input to the matrix LED driver circuit where the transistor BC547 amplifies the signal and helps in the switching process. It is followed by the transistor SL100 connected across the ground of the   matrix flash LED. Whenever a digital '1' input arrives, these transistors are quickly switched and provide ground for the matrix LED thereby making it in switched ON state. At times of digital '0' input, the circuit does not provide ground to the LED and it remains in OFF state. Thus the LED matrix flickers so quickly, though it appears to be constant to our eye.
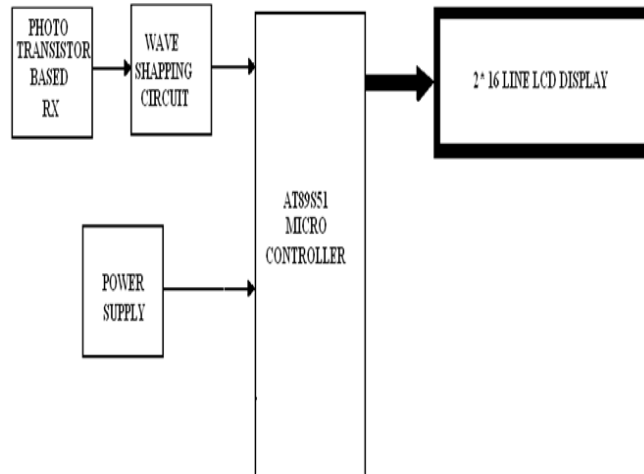
Fig.6 Li-Fi Receiver circuit

The data in the form of light waves is received by using the receiver circuit. The transmitted light waves are received by using a receiver circuit shown above in Fig 6. The received input may not be the same as the transmitted wave due to some interference, hence it is converted to a perfect square wave circuit using a wave shaping circuit. The digital pulse is then converted to ASCII value by microcontroller and is displayed on LCD screen. Microcontroller is powered by a 5V DC supply provided externally [8].

V.   Industrial Automation

In large scale industries, it is difficult to control each and every unit and the devices within. The bulk amount of fans, lights, motors, PC, A/C etc. . . . with manual control at various points makes it difficult to control them individually. For the ease of access, there is a need of centralizing the control of devices. Since the industries might have been equipped with wireless communication system such as Wi-Fi, the automation of devices should be through a medium uninterrupted by those waves.

In industrial automation, Li-Fi can be used as the medium for transfer of control signal. The data is transferred from the transmitter system which is wired to the LED hotspots present in various sections or rooms of an in1dustry. Wherever the Li-Fi light is available there will be a Li-FI receiver wired to the devices to be controlled.

In this paper, industrial automation is realized in parallel with data transmission. The transmitting section is the same one described in section **IV**. The transmitter and receiver section microcontrollers are programmed with independent control code for each devices. The control signal used here helps in switching ON / OFF of the devices. The signal is given as ASCII value from the keyboard input[9].
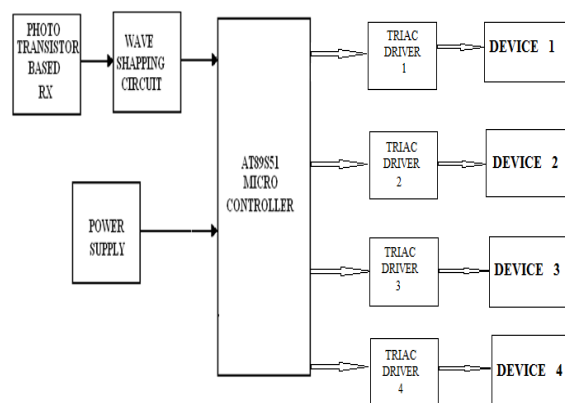
Fig.7 Receiver section of industrial automation system

The control signal reaches the LED matrix after being decoded and digitalized by the transmitter section. The receiver section consists of the similar section as that of data transmission receiver system. But instead of LCD display, there exist a triac driver for each device. The TRIAC drivers are individually controlled by the

microcontroller as programmed. Thus, if a command signal is given from the keyboard input to switch ON Device 2, then it will reach the TRIAC driver 2 through the Li-Fi system and Switch ON the device with the help of the driver.

VI. Biomedical Application

In hospitals, most of the patients are being scanned for variations seen in certain biological parameters of them. It includes blood pressure, sugar level, Heart beat rate, cholesterol level etc. . . Also, these parameters should be made available to different points immediately including Doctor's room, operation theatre, likewise. This is done manually now a days [10].

Introducing a wired technology to transfer data is costly and cannot be easily reassembled. Moving forward with wireless technology is the simplest cost effective method for transfer of these parameters to various locations. Advanced radio wave communications such as Wi-Fi technologies could not be used here as the waves interrupt the equipments in the hospitals. Moreover, the radiation of these waves may affect the health of the patients. So we are moving on to a radiation less Li-Fi technology for transferring scanned data to different locations. Here, a biosensor is used to sense blood pressure and heart beat rate of a patient. Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by the heart. When your heart beats, it contracts and pushes blood through the arteries to the rest of your body. This force creates pressure on the arteries. Blood pressure is recorded as two numbers— the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats). The unit in the biosensor which measures this is called Sphygmomanometer [2].

Parameters	Systolic (mm Hg)	Diastolic (mm Hg)
Hypotension	< 90	< 60
Desired	90–119	60–79
Prehypertension	120–139	80–89
Stage 1 Hypertension	140–159	90–99
Stage 2 Hypertension	160–179	100–109
Hypertensive Crisis	≥ 180	≥ 110

Table 1 Normal blood pressure parameters of an adult

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Fig.8 Biosensor wrapped on hand

The biosensor shown in Figure 8 is shows the reading in the display and is having an output pin which gives out this data in ASCII format. The output of biosensor is interfaced with the transmitter section microcontroller which decodes it and transmit through the Li-Fi transmitter. The receiver section remains the same as in the case of data transmission.

VII.   Future Developments

The future of Li-Fi technology is more flourishing. The recent advancement and researches are focusing on two way communication through it. Soon, this technology could transfer high speed internet through light making a proper replacement for Wi-Fi technology.VLC represents only a fraction of what appears to be a much larger movement towards optical wireless technologies in general. Li-Fi comprises several optical wireless technologies such as optical wireless communication, navigation and gesture recognition applied for natural user interfaces. Thus, it provides a completely new set of optical technologies and techniques to offer users add-on as well as complementary functionalities compared to well-known and established RF services. This could reach from a new user experience regarding communication speeds in the gigabit-class to bridge the well-known spectrum crunch, over to precise indoor positioning or controlling video games, machines or robots with entirely new natural user interfaces. Finally, these and many more could be merged to a full-featured Li-Fi cloud providing wireless services for other future applications as well.

VIII.   Conclusion

The above referred technology has been implemented in the automation of devices and biomedical data transfer. The automation of devices is very effective in large scale industries since it provides a centralized unit to control the devices automatically at low cost. The biomedical apparatus that we have implemented makes it easy to provide patient's medical conditions to all the emergency points keeping us informative and save lifes. 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. 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. If this technology can be put into practical use, we will proceed toward the cleaner, greener, safer and brighter future. Even though this system is efficient, the major limitation is in the range of transfer of data. Moreover, this technology is facing certain drawbacks like shadow, glare, and high intense ambient light such as sunlight and other interferences. The concept of Li-Fi is currently attracting a great deal of interest, not least because it may offer a genuine and very efficient alternative to radio-based wireless. 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 based wireless isn't allowed such as aircraft or hospitals. One of the shortcomings however is that it only work in direct line of sight.

References

Journal Papers:
[1].   Jib-Hun Yun, Geun-Bin Hong and Yong-kab Kim, "A Study on Realization of Visible Light Communication System for Power Line Communication Using 8-bit Microcontroller", KSII Trans. Vol. 11, No. 5, pp. 238-241, October 25, 2010.
[2].   T.Komine and M. Nakagawa, "Integrated System of White LED Visible Light Communication and Power-Line Comm.", PIMRC 2002, .
[3].   T.Komine and M. Nakagawa, "Performance Evaluation of Narrowband OFDM on Integrated System of Power- Line Communication and Visible Light Wireless Communication", IEEE 2006.
[4].   T. T.Komine and M. Nakagawa, "Performance Evaluation of Narrowband OFDM on Integrated System of Power- Line Communication and Visible Light Wireless Communication", IEEE 2006.
[5].   M.Kavehrad, Z. Hajjarian and A. Enteshari, "Energy-Efficient Broadband Data Communications using White LEDs on Aircraft Power-lines", 2008 IEEE.
[6].   S.E.Alavi, A.S.M.Supa'at, S.M.Idrus, S.K.Yusof, "New   Integrated System of Visible Free Space Optic with PLC",3 rd workshop on PLC oct1-2, 2009, udine, Ita
[7].   Yangpo Gao, "Broadband characterization of indoor powerline channel", Proceeding of ISPLC 2004, April, Spain.
[8].   Halid Hrasnica, Abdelfatteh Haidine, Ralf Lehnert, "Broadband Powerline Communications Networks network design", John Wiley & Sons Ltd, Books Inc, ISBN 0-470-85741-2, West Sussex PO19 8SQ, England, 2004.
[9].   P. Amirshahi and M. Kavehrad, "Broadband Access over Medium and Low Voltage Power-lines and use of White Light Emitting Diodes for Indoor Communications", IEEE Consumer Comm. & Networking Conference, 2006.
[10].   T. Komine and M. Nakagawa "Fundamental analysis for visible-light communication system using LEDlights", IEEE Trans. Consumer Electron. . vol. 50, pp.100 107 2004.