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Light Fidelity based Smart Home Automation System

[1] Padmaja Kuruba, [2] Suma KR
[1][2] Global Academy of Technology, Bengaluru,Karnataka

Abstract: **- Today the world runs behind wireless technology to have anything (data), anywhere and anytime. Most commonly used wireless technologies are blue tooth communication and Wi-Fi communication. These technologies yet fail in satisfying the demand of the user. Emerging technology is Light Fidelity (Li-Fi) technology that uses visible light (that is abundant) for data transmission using Light Emitting Diodes (LEDs). These LED's provide illumination and faster switching speed that can be used for data transfer. They operate in the TeraHertz frequency range and provide better opportunities to achieve better data rates compared to Wi-Fi. Research is carried out to commercialize the technology. In the proposed work we use Li-Fi instead of Wi-Fi for data transmission, which is used for smart home control. The speed of Li-Fi is greater than Wi-Fi by at least 100 times, as visible light travels faster than radio waves.**

I. INTRODUCTION

The telecommunication industry in today's scenario is expanding so rapidly that the users are more fascinated about the wireless based communication since it offers a good experience of exchanging the data while navigating their location and switching between different networks. Most devices launched these days include smart phones, laptops, eBook readers, notebooks etc., use the Internet to com-municate with the other sources using free space medium. However, with the increasing number of wireless devices the demands for internet services that are currently available like Wi-Fi, boradband, bluetooth are being insufficient. There is a need to accommodate the growing number of users with uninterrupted data, high quality of services and reduced delay in propagation. In order to come up with a solution to this aforementioned issue, the attention is shifted to a newer technology that has evolved through the abundantly available visible light source. Li-Fi is an alternative to Wi-Fi that transmits data using the spectrum of visible light, has achieved a new break-through, with UK scientists reporting transmission speeds of 10Gbps. This is approximately 250 times faster than super-fast broadband. The term Li-Fi was first introduced by Edinburgh University's Prof Harald Hass, known as visible light communications (VLC). The researchers claim that Li-Fi represents the future of mobile internet due its low cost and high data rates. Both Wi-Fi and Li-Fi transmit data over the electromagnetic spectrum, Wi-Fi utilizes radio waves and Li-Fi uses visible light. The advantage of Li-Fi is that visible light can achieve greater data density approximately 10,000 times more than Radio Frequency(RF) and wide range of frequencies & wavelengths. It includes sub-gigabit and gigabit-class communication speeds for short, medium and long ranges with unidirectional and bidirectional data transfer using line-of-sight or diffuse links and reflections. Li-Fi is not limited to LED or laser technologies or to a particular receiving technique.It is a framework for all of these providing new capabilities to current and future applications requiring higher data rates.

Some of the objectives of Li-Fi are
To transmit data at high speeds(10 Gbps theoretically). To efficiently utilize wide range of visible light spec-
trum available abundantly.

To provide secure communication.

To transmit data by sockets of existing light fixtures.

II. RELATED WORKS

Jyothi Rani et al., [1] have discussed in this work that Li-Fi is a fast and cheap optical version of Wi-Fi, the technology of which is based on VLC. It is a data com-munication, which uses visible light as optical carrier for data transmission and illumination. Harald Haas [2] attempts to clarify the difference between visible light communication and Li-Fi. In particular, it will show how Li-Fi takes VLC further by LEDs to realize fully networked wireless systems. Synergies are harnessed as luminaries become Li-Fi attocells resulting in enhanced wireless capacity providing the

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necessary connectivity to realize the Internet-of-Things, and contributing to the key performance indicators for the fifth generation of cellular systems (5G) and beyond. It covers all of the key research areas from Li-Fi components to hybrid Li-Fi /wireless fidelity (Wi-Fi) networks to illustrate that Li-Fi attocells are not a theoretical concept any more, but at the point of real-world deployment. Harald Haas [3] has discussed about Li-Fi and the key differences to VLC. Misconceptions have been discussed and illustrate the potential impact this technology can have across a number of existing and emerging industries. M. Z. Afgani et al., [4] have discussed wireless communication using white, high brightness LEDs (light emitting diodes). In particular, the use of OFDM (orthogonal frequency division multiplexing) for intensity modulation is investigated. The high peak-to-average ratio (PAR) in OFDM is usually considered as a disadvantage in radio frequency transmission systems due to non-linearities of the power amplifier. It is demonstrated theoretically and by means of an experimental system that the high PAR in OFDM can be exploited constructively in visible light communication to intensity modulate LEDs. It is shown that the theoretical and the experimental results match very closely. It is possible to cover a distance of up to one meter using a single LED. T. Komine et al., [5] have discussed that the advent of the first cellphones in the 1980s marked the beginning of commercial mobile communications. Now, only 30 years later, wireless connectivity has become a fundamental part of our everyday lives and is increasingly being regarded as an essential commodity like electricity, gas, and water. The technology's huge success means we are now facing an imminent shortage of radio frequency (RF) spectrum. The amount of data sent through wireless networks is expected to increase 10-fold during the next five years. At the same time, we don't have enough new RF spectrum available to allocate. In addition, the spec-tral efficiency (the number of bits successfully transmitted per Hertz bandwidth) of wireless networks has become saturated, despite tremendous technological advancements in the last 10 years. The US Federal Communications Commission has warned of a potential spectrum crisis. M. G. Crawford et al., [6] have discussed that in recent years, LEDs have entered the lighting market, offering consumer's performance and features exceeding those of traditional lighting technologies. LEDs are becoming more common in safety signals for highway, automotive and many other applications. In addition to having a longer life and greater durability than incandescent bulbs, LEDs are much more energy efficient than their incandescent counterparts. Since the heat from the junction must be dissipated into the ambi-ent temperature, somehow changing the ambient temperature affects the junction temperature and hence the emitted light. The development of signals using LED as light source is able to respect intensity specifications is not simple.The author describes problems of the temperature dependent changes of LED intensity and color shift. The innovative technique to allow the use of the LEDs in applications with rigorous specifications is discussed. Yuichi Tanaka et al., [7] have dis-cussed that future electric lights will be comprised of white LEDs. White LEDs with a high power output are expected to serve in the next generation of lamps. In this paper, an indoor
visible data transmission system utilizing white LED lights is discussed. The author, in his paper describes that these devices are used not only for illuminating rooms but also used for an optical wireless communication system. This system is suitable for private networks such as consumer communication networks. However, it remains necessary to investigate the properties of white LEDs when they are used as optical transmitters. Based on numerical analyses and computer simulations, it was confirmed that this system could be used for indoor optical transmission. Jia-yuan Wang et al., [8] have discussed visible light communication system using white LED has been demonstrated, in which the transmitter and receiver of visible light communication have been designed and realized. In the experiment, the illumination of the receiving surface in different based on distance between LED and photodiode receiver with different background light. The experiment results show that the data transmit bit rate can be achieved at 111.607 kbps when the average indoor illumination is 40 lx, with the communication distance of our visible light system at 1.5 m.

III. PROPOSED WORK

Li-Fi, the high-speed communication and networking, variant of visible light communication, aims to unlock a vast amount of unused electromagnetic spectrum in the visible light region. Li-Fi works as a signal transmitter with off-the-shelf white LEDs typically used for solid-state lighting and as a signal receiver with a p-i-n photodiode or avalanche photodiode. This means that Li-Fi systems can illuminate a room and at the same time provide wireless data connectivity. Unlike laser diodes, the LEDs produce incoherent light, which means the signal phase cannot be used for data communications. Therefore, the only way to encode data is to use intensity modulation and direct detection. In the process of data communication through the visible light, Keypad is used as the input signal at the transmitter side. The micro controller receives the signal from the keypad and generates two outputs and gives that signal to the DTMF Encoder. The encoder will generate one tone and one frequency for every pressed key. That frequency is amplified by the amplifier circuits and fed into the power LED. At the receiver side light dependent resister will receive the light signal and correspondingly generate an electrical signal proportional to it. This electrical signal is

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processed by a de-modulator circuit (DTMF Decoder), and the output of decoder is then fed to a microcontroller and the microcontroller activates the corresponding load for the pressed key.

IV. DESIGN OF THE PROPOSED WORK

The basic idea behind this communication scheme is transmission of Data through illumination.The key concept of Li-Fi technology is high brightness LEDs. The on-off activity of LEDs enables a kind of data transmission using

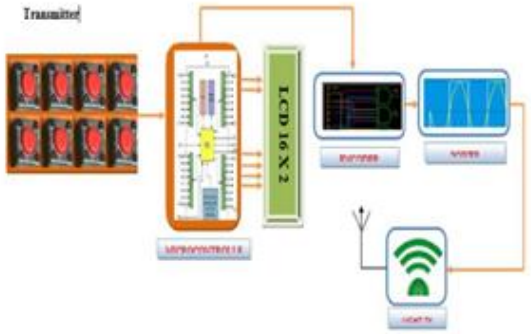

Fig. 1: Transmitter Module

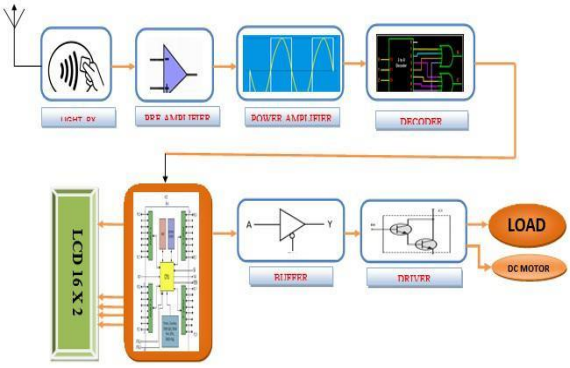

Fig. 2: Reciever Module

binary codes mode, however the human eye cannot perceive this change and the LEDs appear to have a constant intensity. Switching ON an LED is a logical '1' switching it OFF is a logical '0'. A light sensitive device (LDR) receives the signal and converts it back into original data. This method of using rapid pulses of light to transmit data is called Visible Light Communication the basic principle of VLC. It has gained a huge popularity in few years of its invention. Such technology has brought not only greener but safer and cheaper future for communication. The proposed system includes transmitter, receiver and power supply. The transmitter module comprises of Light transmitter, Microcontroller (89C51), encoder, LCD and power supply. The receiver module consists of Light re-ceiver, preamplifier, power amplifier, decoder, Microcon-troller, LCD,driver, buffer and the payload. The software used for this work includes Keil compiler uVision 3, with Embedded C/ Assembly and WLPRO Pro-grammer. The transmitter and the receiver module is shown in figure 1 and 2

The description of the each module is as follows

A. Li-Fi transmitter and receiver

Li-Fi is implemented using white LED light bulbs at downlink transmitter. These devices are used for illumination only by applying a constant current. By fast and subtle

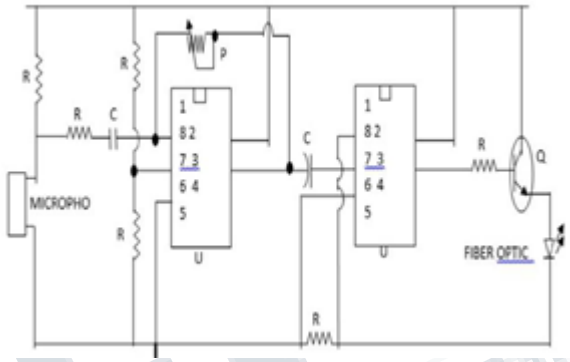

Fig. 3: Circuit diagram of LiFi Transmitter

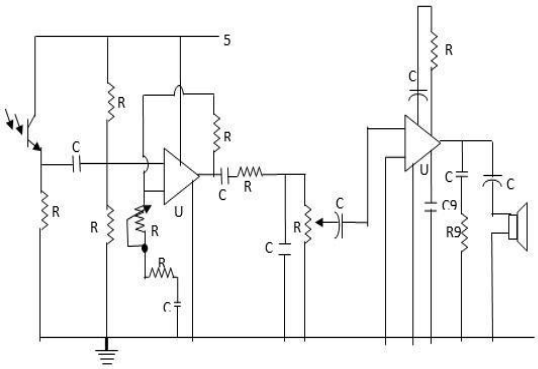

Fig. 4: Circuit diagram of LiFi Receiver

variations of the current, optical output can be made to vary at extremely high speeds. This variation is used to carry high speed data. The circulit diagram of Transmitter and Receiver is shown in the figure 3 and figure 4

B. Microcontroller

The Atmel AT89 series is an Intel 8051-compatible family of 8 bit microcontrollers manufactured by the Atmel Corporation. Based on the Intel 8051 core, the AT89 series remains very popular as general purpose microcontrollers, due to their industry standard instruction set, and low unit cost. This allows a reusability of the code without modification in new applications.

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C. Power supply unit
The power supply needs two voltages viz., +12 V & +5 V, as working voltages. Hence specially designed power supply is constructed to get regulated power supplies.

D. Preamplifier
A preamplifier is an electronic amplifier that prepares a small electrical signal for further amplification or process-ing. A preamplifier is often placed close to the sensor to reduce the effects of noise and interference. It is used to boost the signal strength to drive the cable to the main instrument without significantly degrading the signal-to-noise ratio(SNR).

E. Power amplifier
An audio power amplifier is an electronic amplifier that amplifies low-power audio signals (signals composed pri-marily of frequencies between 20 - 20 000 Hz, the human range of hearing) to a level suitable for driving loudspeakers. It is the final electronic stage in a typical audio playback chain.

F. Buffers
Buffers do not affect the logical state of a digital signal (i.e. a logic 1 input results in a logic 1 output whereas logic 0 input results in a logic 0 output). Buffers are normally used to provide extra current drive at the output but can also be used to regularize the logic present at an interface.

V. METHODOLOGY OF THE PROPOSED WORK

Li-Fi is implemented using white LED light bulbs at downlink transmitter as shown in the figure 3. These devices are used for illumination only by applying a constant current. By fast and subtle variations of the current, optical output can be made to vary at extremely high speeds. This variation is used to carry high speed data. The Li-Fi transmitter has pre-amplifierication and a power amplification. At the preamplifier circuit in U1 picks the transducer output ,which catches the very low pitch sound waves and pre-amplifier amplifies voltage sufficiently. The condenser microphone which is biased through R1 changes its internal-resistance with respect to the picked sound waves. This varying sig-nal drives the U1 ic LM 741 through coupling capacitor C1. Hence the corresponding amplified output signals are observed at terminal 6 of IC U1 & Through P1 we are controlling the gain. The input signals from condenser microphone and output signals at 6 terminal are coupled by capacitors C2 to power amplifier input terminal 3 of IC U2 . In power amplifier stage. Amplifies both current and voltage sufficiently then transmitted through light transmitter .

The Li-Fi Receiver have two stages pre-amplifier and power amplifier as shown in the figure 4. At the pre-amplifier stage U1 picks the transmitted signal through LDR RX, which catches the very low pitch sound waves .In pre-amplifier amplifies the voltage sufficiently The light Rx Transistor (LDR) which is biased through R7 & voltage di-vider circuit is formed using R1 & R8 resistors. The varying signal drives the U1 IC LM 358 through coupling capacitor C2. Hence the corresponding amplified output signals are observed at terminal 7 of IC U1. we are controlling the volume Through R5 . The output signals from terminal 7 of U1 are coupled by capacitors C5 to power amplifier input terminal 3 of IC U2 .The Capacitor C4 & R3 is used for gain control from 20 to 200dB. In power amplifier stage. Amplifies both current and voltage sufficiently, then fed to with the help of coupling capacitor C8 speaker.

Fig. 5: Device 1 is ON

Fig. 6: Device 1 and Device 2 both are ON

VI. RESULTS

Here we have taken Home automation as an example payload for controlling multiple devices. The payload here is controlled by giving the input from the keypad and processes by transmitter module and receiver module to drive the different devices. The following figure5 ,6 and 7 depicts the results.

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Pressing key 1 turns the device 1 ON with an output of 230V and it is displayed on the LCD
Pressing key 2 turns the device 2 ON with an output of 230V and it is displayed on the LCD
Pressing key 3 turns the device 2 OFF with an output of 0V and it is displayed on the LCD
Pressing key 4 turns the device 1 OFF with an output of 0V and it is displayed on the LCD

VII. CONCLUSION

Varying results can be obtained in various different ways if Li-Fi technology is put into use effectively it can serve a lot of purpose. For example, every light source can be used in a way similar to the way in which the Wi-Fi hotspots are used to transmit the data wirelessly. The concept of Li-Fi will make the communication faster and more effective in future in various spheres across the world. This will also reduce the electrical overhead, make the environment

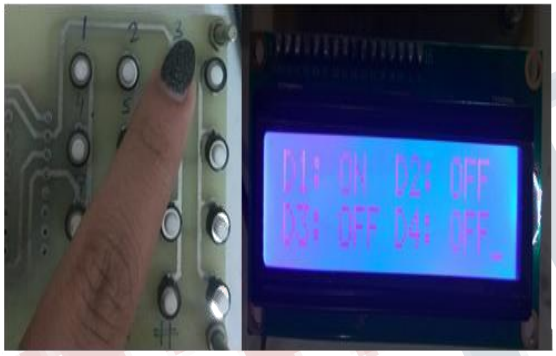

Fig. 7: Device 1 ON and Device 2 is OFF

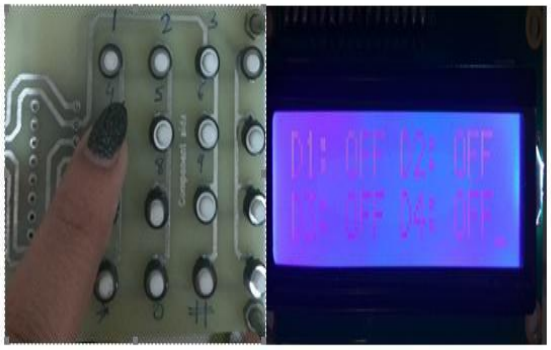

Fig. 8: Device 1 and Device 2 are OFF

eco friendly, to some extent the environment will be more radiation free zone. With the increasing population and the congestion net-work transmission of data through Li-Fi will make the lives simpler and easier. It attracts a great deal of interest in business in the communication sectors and will soon be able to utilize this technology at greater speeds in every field of communication. This ultimately reduces the time consumption and the work outcome is effectively increased.

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