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High Speed Data Transmission of Images over Visible Light Spectrum using PIC Microcontroller

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Abstract: ***A large demand for wireless data is making the radio spectrum highly congested and this is only getting worse. Bandwidth required for RF communication is rapidly getting depleted. Researches on hazards of RF have found that extreme RF radiations have adverse effect on environment. Light on the other hand does not contribute to this RF congestion since it lies in the visible light spectrum.***

'High speed data transmission of images over visible light spectrum using PIC Microcontroller' uses a controller with light fidelity uniquely intended for secure and high speed data transmission. It is inquisitive to build up a transmitter and receiver to use light as a medium which must send the data obtained from sensor to light of its own and should exchange information through secured remote system with low bandwidth, which must play all the procedure without human interference and must carry out the work which current system is doing. It will be implemented by building up a framework which converts electrical signal to light and light back into electrical signal.

The essential block comprises of control unit, sensory and light conversion. Expected outcome of this outline will utilize dedicated hub for every user with a secured transmission with fixed sensors and dedicated low power controller with a receiver will be interfaced.

I. INTRODUCTION

The idea of Li-fi is currently attracting a great deal of interest, not least because it offers a genuine and very efficient alternative to RF.As a growing number of people and their recent device access wireless internet, the airwaves are becoming increasingly clogged and unavailability of free bandwidths to every device, making it more and more difficult to get a reliable, high speed signal. The opportunity to exploit a completely different part of the electromagnetic spectrum is very interesting. Li-Fi has other advantages over Wi-Fi, such as safe to use at nuclear power plants, thermal power stations where Wi-Fi cannot be used. In these stations RF waves can be harmful and can cause accident, to communicate in such regions only visible light spectrum can be safe. Apart from adverse regions Li-fi can also be used in all places where Wi-Fi can be used. Li-fi is present wherever there is availability of light, in turn eradicating the necessity of having hot-spots only at selected places. There are four criterions to judge on the working of Li-Fi and Wi-Fi that is, capacity, efficiency, availability and security. Both Li-fi and Wi-Fi uses electromagnetic spectrum for data transmission, but whereas Wi-Fi utilizes radio waves, Li-Fi uses visible light communication in the range of 100Mbps. This paper deals with the VLC which provides a wide and fast data rate upto 500Mbps and the comparison is made between Wi-Fi and Li-Fi technology. It discusses the working, implementation and applications of Li-Fi technology.

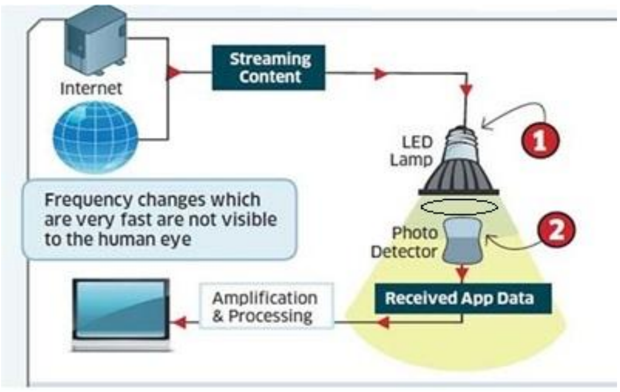

Figure 1: Basic Li-Fi based system

Li-Fi has more capacity in terms of bandwidth in visible region therefore it does not poke its nose in other communications which uses radio frequency range, without taking its frequency bands.

II. LITERATURE SURVEY

Li-Fi is a revolution of twenty first century data communication. Li-Fi is a technology which is very similar to the fiber optics communication where the data is transmitted through a LED at a higher intensity. Li-Fi technology can be applied to many different fields like navigation, undersea communication and etc. Li-Fi can also be used to improve security system in many different fields.

H. Elgala, R. Mesleh and H. Haas[1] published the paper "Indoor Broadcasting via White LEDs and OFDM" in which they designed a prototype which allows investigating the influence of the electrical signal-to-noise ratio (SNR), constellation order, and channel coding on the bit-error performance. Theoretical and experimental results on optical path loss show close match. The installation of a wireless network based on an existing interior lighting infrastructure would be easier and more prudential than setting up a separate IR network.

WANG Jia-yuan, ZOU Nian-yu, WANG Dong, IRIE Kentaro, IHA Zensei, NAMIHIRA Yoshinori[2] designed a visible light communication system using white light emitting diode (LED) which has been proposed and demonstrated, in which the transmitter and receiver of visible light communication have been designed and realized. The illumination on the receiving surface in different distances between LED and photodiode receiver has been tested, and the effect of background light has been considered. The experiment results show that the data transmit bit rate can be achieved at 111.607 kbit/s when the average indoor illumination is 40 lx, with the communication distance of our visible light system at 1.5 m.

Chi-Wai Chow, Chung-Yen Chen and Shih-Hao Chen [3] have designed the VLC systems reported in the published paper which are mainly based on PIN receivers. It is highly desirable if these VLC signals can be detected by using built-in complementary metal–oxide–semiconductor (CMOS) cameras as Receivers to provide flexible and low-cost wireless communications. However, using the CMOS camera is challenging. In this paper, it is proposed and demonstrated, a VLC link using a CMOS mobile phone camera as Rx. By using the rolling shutter effect of the CMOS sensor, the VLC data rate can be significantly enhanced. Firstly, a second-order polynomial fitting is used to mitigate the "blooming effect" (saturation of pixels) of the CMOS sensor. In order to extend the VLC transmission distance and mitigate the influence of the background noise, it is also proposed and demonstrated using histogram equalization and Sobel filter to enhance VLC signal performance. Finally, a third-order polynomial fitting is used to define the threshold. The experimental results show that significant improvement of bit error rate (BER) for about an order of magnitude under different illuminances can be achieved.

Kirti Tanwar and Stuti Gupta [4] proposed an in-the-classroom technology solution that has transformed teaching and learning, reaching out to millions of schools and colleges. Using Smart class teachers show the class a 2D/3D animation on a large screen. They can explain the fine points of the topic, zoom in to show the relevant visuals, freeze and annotate when and where they need to emphasize along with engaging animations, colours, and sounds The teachers gain complete attention and interest of every child in the class using Li-Fi Technology. Li-Fi uses light instead of radio waves to transmit information means replace the light by the energy efficient LED lightening which could enhance the capability and functionality by providing light in high speed data communication using Li-Fi modem.

III. EXISTING SYSTEM

Traditional Wi-Fi uses radio signals to transmit data to devices such as phones and laptops. Currently, Wi-Fi carries about half of the world's internet transmissiond. This percentage is expected to grow in coming yearsas more people get online and as the "Internet of Things" (objects with internet connectivity,from remotely programmable coffee makers to smart cars) expands. Wi-Fi is supported by many applications and devices including video game consoles, home networks, PDAs, mobile phones, major operating systems and other types of consumerelectronics. Any products that are tested and approved as "Wi-Fi Certified" by the Wi-Fi Alliance are interoperable with eachother, even if they are from different manufacturers. For example, a user with a Wi-Fi Certified product can use any brand of access point with any other brand of client hardware that is also "Wi-Fi Certified".

Products that pass Wi-Fi certification are required to carry an identifying seal on their packaging that states "Wi-Fi Certified" and indicates the radio frequency band used (2.5GHz for 802.11b, 802.11g, 802.11n and 5GHz for 802.11a).

The concept of transmitting data through the visible light spectrum is not new. Alexander Graham Bell transmitted sound via a beam of sunlight in 1880 using a photophone, a sort of solar-powered wireless telephone. Wi-Fi networks have no physical connection between sender and receiver as they use radio frequency (RF) – a frequency within the electromagnetic spectrum associated with radio wave propagation. When an RFcurrent is supplied to an antenna, an elctromagnetic field is created, which then propagates through space.

Li-Fi vs Wi-Fi

Table 1: Comparison of speed between different wireless technologies

TECHNOLOGY	SPEED
Wi-Fi-IEEE 802.11a/b/g/n	600 Mbps
Bluetooth	3 Mbps
IrDA	4 Mbps
Li-Fi	More than 1 Gbps

The visible light spectrum is much wider than the microwave spectrum. Hence, more bandwiths can be achieved using Visible Light Communication(VLC).

Table 2: Electromagnetic spectrum table

Spectrum	Frequency
Gamma Ray	More than 10 EHz
X-Ray	30 EHz to 30 PHz
Ultraviolet	30 PHz to 790 THz
Visible	790 THz to 405 THz
Infrared	405 THz to 300 GHz
Microwave	300 GHz to 300 MHz
Radio	300 GHz to 3 Hz

IV. Design Methodology

The project work includes both hardware and software backbone. The hardware design methodology includes the block diagram of the transmission and reception part of the entire project.

PIC18F46K22 Microcontroller

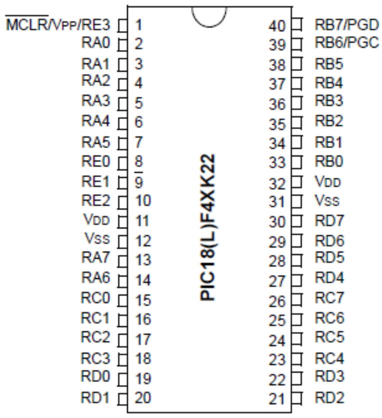

Figure 2:Pin diagram of PIC18F46K22 microcontroller

The PIC18F46K22 microcontroller provides high computational performance at economical price with the addition of high endurance, Flash program memory. On top of these features, the PIC18F46K22 introduces design enhancements that makes this microcontroller a logical choice for many high performance, power sensitive applications.

The microcontroller offers 10 different oscillator options allowing users a wide range of choices in developing application hardware such as four crystal modes, two external clock modes, a PLL frequency multiplier.

The PIC18F46K22 microcontroller provides the following standard features:

High-Performance RISC CPU which has data memory (SRAM - 3896 bytes, EEPROM - 1024 bytes), Flash memory of 64KB. It has 35 I/O pins and one input-only pin. It has 16-bit wide instructions, 8-bit wide data path. It has four 16-bit timers and three 8-bit timers.

It provides few special features such as High/Low-Voltage Detection module, Programmable Brown-Out Reset, Extended Watchdog Timer, In-Circuit Serial Programming and In-Circuit Debug.

Graphical LCD

GLCD display technology is a subsequent technology to CRT. CRT displays use electron-gun to generate a pixel based display over monitor screens. It is mostly used in display screens of different gadgets and electronic devices. This technology uses the concept of manipulating tiny crystals of a contained liquid crystal solution through precise electronic signals to perform graphic display operations over a two-dimensional physical screen.

Graphical LCDs offer multiple significant advantages over traditional CRT-based visual display units. Advantages of GLCD include thin dimensions and compactness, more detailed display of 3-D objects, lower power consumption, and lighter weight. Furthermore, all these features have considerably contributed towards integration of these visual display units into commercial portable electronic items.

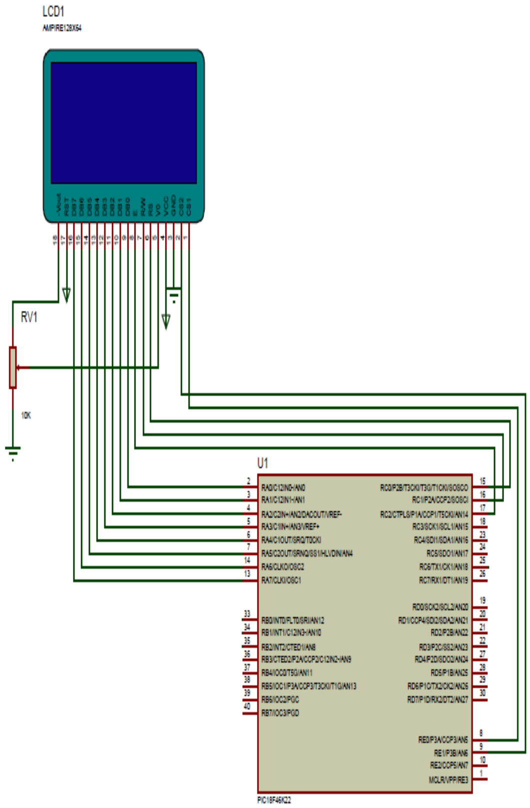

Figure 3:Interfacing GLCD with PIC microcontroller

Port A, port C and port E of the microcontroller are used as interfacing ports. Port A of microcontroller is interfaced with data bus of GLCD. RC2 acts as enable for the GLCD. RC0/OSC0 provides clock frequency for Read/Write operation and RC1/OSC1 helps in register selection. RE0 and RE1 of port E are used in chip selection of the GLCD.

Block Diagram

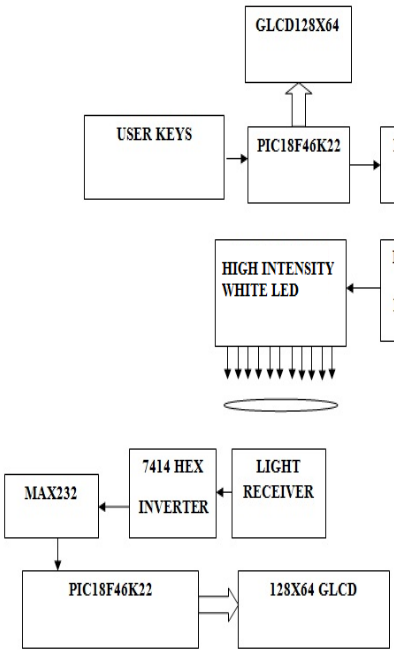

Figure 4:Block diagram of Li-Fi system

The transmitter consists of the source device that has data to transmit to the receiver. PIC18F46K22 is a 40 pin IC which is used to store and modulate the source data and has a Flash Memory of 64kB and has a processing speed of 16 MIPS. MAX2232 is used in the conversion of voltage level required to make TTL devices compatible with pc serial port and vice versa. It can be powered by a single +5V power supply and its output can be +7.5V. 7414 Hex Inverter is a Schmitt-Trigger inverter. Because of its Schmitt-Trigger action it has different input threshold levels for positive and negative going signals. The brightness of the LED changes with respect to modulated signal. The changes in brightness due to this signal will not visible to human eye. We only see static illumination of white LED. A MOSFET LED Driver is used to power the high intensity white LED.

The receiver block consists of a photodiode which receives the light from the LED. The received data in the form of light is filtered of ambient light. MAX232 does the same operation as in the transmitter section. The microcontroller demodulates and stores the received data array. The image is then displayed on the GLCD.

V. CONCLUSION

Images constitute a huge part of the internet's traffic these days and hence, its transmission must be fast, efficient and most importantly secure. Li-Fi is the future of wireless communication system which is currently dominated by radio frequencies. It provides broader bandwidths which translate to high trans-reception speeds. Li-Fi is a real alternative to the radio wireless systems. Since light does not pass through walls and other obstacles, the data from the light is concentrated to a particular area and hence it is difficult to hack into. Thus, Li-Fi provides a secure communication platform for text, image and video files. Internet of Things is one such example in which street lights, automotive lights, home lights etc. can be used to exchange data discretely and provide a gateway to a truly automated world.

Li-Fi is still in research and is an upcoming technology. Its applications are many but there will be many more in the future such as in medical applications, internet access in aircrafts, underwater communication and border security.

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Aditya Bharadwaj, is pursuing his Bachelor of Engineering degree in NIE Institute of Technology, Mysuru. His research interests lie in Optical Communication, Artificial Intelligence, Quantum Computing and Big Data Networks. His current research emphasizes on bringing Li-Fi technology to the real world applications including contactless payments, Internet of Things and pico-networks.