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LI-FI Technology : Data Transmission Through Visible Light

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Abstract - The role of communication is very critical in day to day life. Communication can be of two types: wireless or wired communication. Wireless communication is usually preferred over wired communication. Light Fidelity is abbreviated as Li-Fi. In 2011, in a TED Global Talk on Visible Light Communication, a German physicist Harald Haas introduced this technology. Li-Fi employs the visible light band within the spectrum of electromagnetic waves. This band is ten thousand times the size of the RF band and cannot be overloaded. Light waves may be modulated to hold large portions of simultaneous data, at very high speeds. Data transmission using Li-Fi is hundred times faster when compared to data transmission using Wi-Fi. In this paper, we present new mode of communication between two laptops or PC's using Li-Fi technology. Li-Fi refers to wireless communication systems that use light from LEDs as a medium rather than conventional RF, as used in Wi-Fi technology. Li-Fi yields enhanced bandwidth, performance, connectivity & security compared to Wireless Fidelity. One of the benefit of Light Fidelity is that it can be used in electromagnetically subtle conditions such as airlines and thermonuclear energy stations without any interference

Key Words: Li-Fi Communication, Microcontroller, USB-TTL Converter, MAX232, LED.

1. INTRODUCTION

In the era of overcrowded (data communication) world, Li-Fi is a new way of wireless communication that uses LED lights to transmit data wirelessly. Transmission of data is one of the most important day to day activities in the fast growing world. The current wireless networks that connect us to the Internet are very slow when multiple devices are connected. Also with the increase in the number of devices which access the Internet, the availability of fixed bandwidth makes it much more difficult to enjoy high data transfer rates and to connect a secure network. Radio waves are just a small part of the electromagnetic spectrum available for data transfer. Li-Fi has got a much broader spectrum for transmission compared to conventional methods of wireless communications that rely on radio waves. The basic ideology behind this technology is that the data can be transferred through LED light by varying light intensities faster than the human eyes can perceive. This technology uses a part of the electromagnetic spectrum that is still not greatly utilized- The Visible Spectrum, instead of Gigahertz radio waves for data transfer. The idea of Li-Fi was introduced for the first time by a German physicist Harald Hass in the TED (Technology, Entertainment, Design) Global talk on Visible Light Communication (VLC) in July 2011, by referring to it as "data through illumination". He used a table lamp with an LED bulb to transmit a video of a blooming flower that was then projected onto a screen. In simple terms, Li-Fi can be thought of as a light-based Wi-Fi i.e. instead of radio waves it uses light to transmit data. In place of Wi-Fi modems, Li-Fi would use transceivers fitted with LED lamps that could light a room as well as transmit and receive information. By adding new and unutilized bandwidth of visible light to the currently available radio waves for data transfer, LiFi can play a major role in relieving the heavy loads which the current wireless system is facing. Thus it may offer additional frequency band of the order of 400 THz compared to that available in RF communication which is about 300 GHz. Also, as the Li-Fi uses the visible spectrum, it will help alleviate concerns that the electromagnetic waves coming with Wi-Fi could adversely affect our health. By Communication through visible light, Li-Fi technology has the possibility to change how we access the Internet, stream videos, receive emails and much more. Security would not be an issue as data can't be accessed in the absence of light. As a result, it can be used in high security military areas where RF communication is prone to eavesdropping.

Li-Fi which can be the future of data communication appears to be a fast and cheap optical version of Wi-Fi. Being a Visible Light Communication (VLC), Li-Fi uses visible light of electromagnetic spectrum between 400 THz and 800 THz as optical carrier for data transmission and illumination. It uses fast pulses of light to transmit information in wireless medium. The main components of a basic Li-Fi system may contain the following: a) A high brightness white LED which acts as transmission source. b) A silicon photodiode with good response to visible light as the receiving element.

1.2. LITERATURE REVIEW

Now-a-days, majority of us are familiar with Wi-Fi (Wireless Fidelity), which generally uses 2.4, 5 GHz radio frequencies to transmit data wirelessly. But, these radio waves are harmful for living beings. So, the best alternative for this problem is Visible Light Communication (VLC), where LED lights are used to transfer the data wirelessly. VLC is recently referred as LiFi. It is a term often used to describe high speed VLC in application scenarios where Wi-Fi might also be used. The term Li-Fi is similar to Wi-Fi with the exception that light rather than radio is used for transmission. Professor Harald Haas, from the University of Edinburgh in the UK, is widely recognized as the original founder of Li-Fi. By the end of AUGUST 2013, data rates of over 1.6 GBPS were achieved using Li-Fi (light fidelity). In APRIL 2014, the Russian company Stins Coman has announced the development of a Li-Fi wireless local network called Beam Caster. They achieved data rates of 1.25 GBPS. With Li-Fi, we can able to

communicate under water, gives more security compares to Wi-Fi as light cannot pass through wall of the room.

2. PROPOSED SYSTEM

The working of Li-Fi is very simple. There is a light emitter on one end i.e. an LED transmitter, and a photo detector (light sensor) on the other. The data input to the LED transmitter is encoded in to the light (technically referred to as Visible Light Communication) by varying the flickering rate at which the LEDs flicker 'on' and 'off' to generate different strings of 1s and 0s. The on off activity of the LED transmitter which seems to be invisible (The LED intensity is modulated so rapidly that human eye cannot notice, so the light of the LED appears constant to humans), enables data transmission in light form in accordance with the incoming binary codes: switching ON a 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.
In a typical setup, the transmitter (LED) is connected to the data network (Internet through the modem) and the receiver (photo detector/light sensor) on the receiving end receives the data as light signal and decodes the information, which is then displayed on the device connected to the receiver. The receiver (photo detector) registers a binary '1' when the transmitter (LED) is ON and a binary '0' when the transmitter (LED) is OFF. Thus flashing the LED numerous times
or using an array of LEDs (perhaps of a few different colours) will eventually provide data rates in the range of hundreds of Mbps. T.

A. Transmitter Section:

The transmitter has the following operations: selection of the document for transmission, then extracts the data in the form of 1's and 0's. codes it to serial data on a GPIO, processes the data and turns the LED ON or OFF according to the data encoded.

- Text to be transmitted is given as an input to the transmitter PC consisting of a python program reserved for serially transmitting the text to Raspberry Pi.
- The python program in the transmitter PC serially sends the text to Pi via a USB to TTL converter cable which is connected to the COM3 serial port of the transmitter PC with the baud rate of 9600.
- A python code is now written in Raspberry Pi's Thonny platform to convert the received text into binary bits The python program extracts the bits from the text and sends them to the LED connected to Pi. When the transmitted bit is '1' the LED turns on and when the transmitted bit is '0' the LED is switched off.

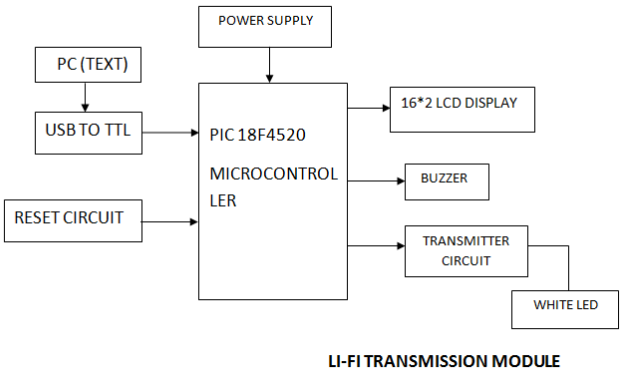

Fig -1: Block Diagram (Transmitter Section)

B. Receiver Section:

The receiver module requires almost the same components as that of the transmission module. The primary difference is the solar panel. Receiver module has the function of receiving the transmitted bits from LED on the solar panel & sending it to Raspberry Pi and then to the receiver PC via the USB to TTL converter. The configuration of Raspberry Pi remains same as the one used in transmitter module.
The receiver module does the reverse engineering of the operations in the transmitter module. The light encountered from the Light Emitting Diode is captivated by the photosensitive component which plays the role of a sensor and transfers the output to the receiver PC and the original text is recovered using python code. Solar panels cannot be directly connected to Raspberry Pi because the Raspberry Pi has no analog GPIO pins unlike in an Arduino. Analog sources like solar panel to be connected to the Raspberry Pi, what is called as an ADC is needed (analog-to-digital converter).

- The photosensitive component detects the On & OFF of the LED and is sent to the Raspberry Pi of the receiver.
- The python program written on the Raspberry Pi of the recipient sends 1/0 by means of sequential port to the processing software. Processing software receives the data in the serial port.
- The processing software has code for reading the data on the serial port, retrieving the bytes and displaying the original data sent from the transmitter and displaying it on the Receiver PC.

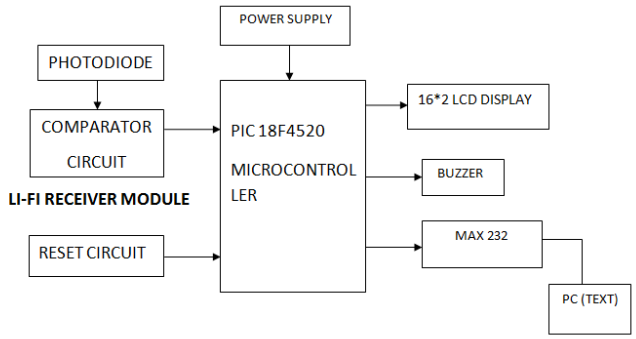

Fig -2: Block Diagram (Receiver Section)

Fig -3: PIC18f4520

2.1 PIC 18f4520:

Data Memory up to 4k bytesn Data register map - with 12-bit address bus 000-FFF

- Divided into 256-byte banks
- There are total of F banks
- Half of bank 0 and half ofbank 15 form a virtual (oraccess) bank that is accessibleno matter which bank isselected – this selection isdone via 8-bits
- Program memory is 16-bits wide accessed through a separate program data bus and address bus inside the PIC18.
- Program memory stores the program and also static data in the system.
- On-chip External
- On-chip program memory is either PROM or EEPROM.
- The PROM version is called OTP (one-time programmable) (PIC18C) The EEPROM version is called Flash memory (PIC18F).
- Maximum size for program memory is 2M n Program memory addresses are 21-bit address starting at location 0x000000

2.2 LI-FI Module:

LI-FI is transmission of data through illumination ,ie sending data through an LED light bulb that varies in intensity faster than human eye can follow

Operational procedure is very simple, if the led is on, it transmits a digital 1, if its off transmits a 0. 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. We have to just vary the rate at which the LED's flicker depending upon the data we want to encode

On one end all the data on the internet will be streamed to a lamp driver when the LED is turned on the microchip converts the digital data in form of light A light sensitive device (photo detector) receives the signal and converts it back into original data. This method of using rapid pulses of light to transmit information wirelessly is technically referred as Visible Light Communication.

- Simple mode of working : Conect Tx of LIFI to Rx of TTL , Rx of LIFI to Tx of TTL
- Power supply 12v (5v regulator is on board)
- LED source is soldered to Tx board.
- ATMEGA8 IC used on Tx & Rx boards for handling serial data.

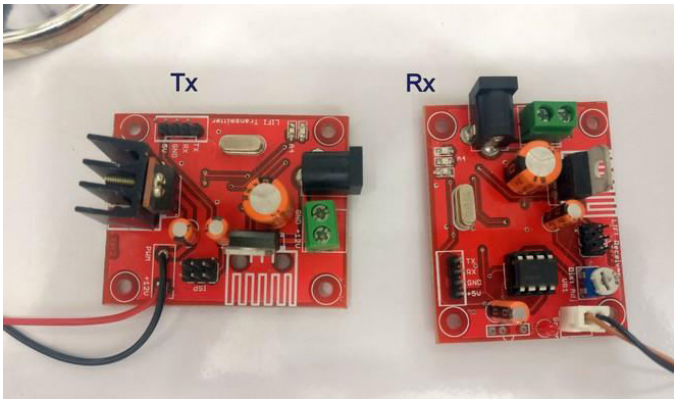

Fig -4: Li-Fi Modules (Tx, Rx)

2.3 USB To TTL Converter:

This is HL-340 USB serial port (COM) USB to RS232 USB Nine Serial Line Support Windows 7-64. USB to RS232 conversion cable for USB and serial devices easily connect serial devices with features such as Plug and play, hot-swappable.

Can meet the notebook connected to the serial device, apply to mini-phones, digital cameras, communication MODEM, ISDN terminal adapters, LED control card.

Features:

1. Single crystal 12M Tablet 340 USB port to serial port communication.
2. USB1.1/2.0 compliant solution.
3. Built-in 128 byte TX/512 byte RX buffer.
4. Supports the auto-Handshake Protocol.

Fig -5: USB to TTL converter

2.5. LCD display:

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD.

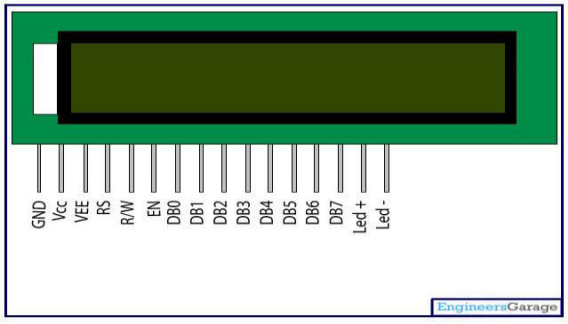

Fig -6: LCD Display

3. ADVANTAGES

Efficiency: The usage of light from the Light Emitting Diodes that is being previously used for lighting purposes in home, workplaces & mall etc. will reduce energy usage. Thus, data transmission requires zero additional power, which makes it very cost-effective & energy intensive.
High speed: Combining lower latency, higher bandwidth & higher-power performance, allow Light Fidelity achieve higher data speeds, i.e. 1 Gbps or even more.
Availability: This isn't a problem because light sources are everywhere. There can be net where there's a supply of sunshine. There are bulbs in all places -in houses, workplaces, business units and even craft, which might be used for transmitting data.
Cheaper: Not only do Light Fidelity need minimum elements in order to work it also require only a small amount of power for transmitting data.

Security: Li-Fi's major benefits include safety. Owing to the fact that light can't penetrate into non-transparent devices, Li-Fi connectivity can only be only availed by users in a restricted zone & can't be accessed & exploited by users staying outside the restricted zone

3. CONCLUSIONS

Li-Fi is the trend of today and near future. It is one of the cheapest and efficient modes of data transfer. These methods can be used to transfer data between two PC. Quite obviously development in research on Light Fidelity will reveal that it'll would available to every individual in the coming times. This technology will benefit maximum of the experimentations, undersea studies & verbal exchange, scientific technology, or even in navy sectors for its useful resource in secured verbal exchange. A top-notch alternate in everyday life on every factor will show up if Li-Fi generation supersedes Wireless Fidelity and different broadband connections. While Li-Fi has many blessings, records offer us one-of-a-kind exposure to factors and facts added at a very fast rate, are this technology's biggest challenge. In this task, an actual-time textual content broadcast prototype off the home LEDs are used, it's far envisaged that the usage of industrial LED's could bring about higher distances of transmission. VLC continues to be in a totally early level. The interest in VLC is growing throughout the world and we can quickly anticipate many actual-international packages. LI-Fi is a fast and cheap wireless-communication technique. There is a growing demand for better bandwidths, faster, and extra at ease data transmission in addition to environmental and surely human friendly is all fulfilled by using Li-Fi.

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