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Data Communication Using Li-Fi

Ms. Bhagyashree M. Meshram (Author)
M. Engg.(Part-time)- Final Year
Computer Science & Engineering
PRMITR, Badnera, Maharashtra, India
e-mail: bhagyamesh@gmail.com

Dr. V. M. Deshmukh *(Author)*
Head of Department
Computer Science & Engineering
PRMITR, Badnera, Maharashtra, India
e-mail:vmdeshmukh@mitra.ac.in

Abstract—Wireless data transmission demand is increased over the years. But due to lack of radio frequency spectrum and hazardous electromagnetic waves comes out from it Li-Fi appears as a new cheaper, greener, and healthier alternative to traditional Wi-Fi. Presently there are two trends being seen in the world of Wireless communication: First, the enrichment or extension of wireless services & second being increased in demand by users for these services. The need is fulfilled by RF spectrum but the usage is very limited. So the emerging technology-Li-Fi came into picture, which uses visible light as a source of communication. The recent advancement in the wireless communication world has made VLC as one of the high-speed, efficient, secured and cheaper optical wireless communication technology. [12] This research paper focuses on required hardware for transmission of text Li-Fi system. The PCB of Transmitter and Receiver are designed by using PCB Artist 4.0 tool. The Microcontroller ATMega16 has been used for the purpose of performing operation at transceiver section. Its programming is done by using AVR studio. Successful transmission and reception of text is carried out on the transceiver. Hence this research paper shows an innovative way of designing a transceiver with low cost electronic hardware components and using already available white LED light bulb. This Li-Fi technology envisions a future where data for smart phones, laptops and tablets will be transmitted in an economic and ecofriendly medium of light in room. [7]

Keywords- *Photodiode; ATMega16; LM324; VLC(Visible Light Communication);PCB(Printed Circuit Board);Gbps*

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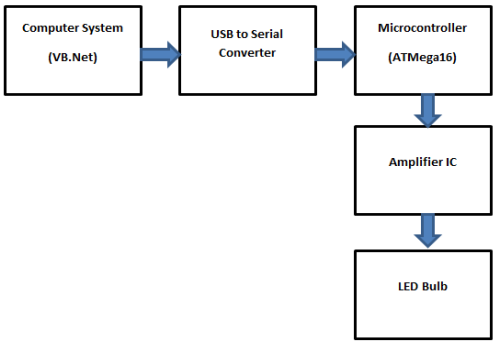
I. INTRODUCTION

Visible light communication (VLC) is the term used for an optical wireless communication system, responsible to convey information by modulating light, visible to the human eye. Communication can be achieved by switching LED lights ON and OFF at a speed higher than what is perceptible to the human eye. Human eyes can notice changes in light brightness and power, but they cannot perceive light which is switched ON and OFF rapidly. A photodiode can easily recognize the rapid ON-OFF modulation. A photodiode is a photo detector; it produces an electrical current which is proportional to the optical power. This simple principle makes possible VLC technology which supports both illumination and wireless communication using an LED. [11]Unlike Radio Frequency wireless communication, where specialized tools are needed to find a hotspot, however the presence of a VLC service area will be detected easily. Li-Fi makes use of a freely available LED light which is unlicensed spectrum and is not affected by RF noise. Moreover, most indoor places would have a sufficient amount of light and also provides an additional security since Li-Fi cannot penetrate through walls. The usage of Li-Fi is possible in different environments such as in Hospitals, Airplanes, and Underwater etc. where Wi-Fi is not allowed due to security reasons and its hazardous radio waves. [4]

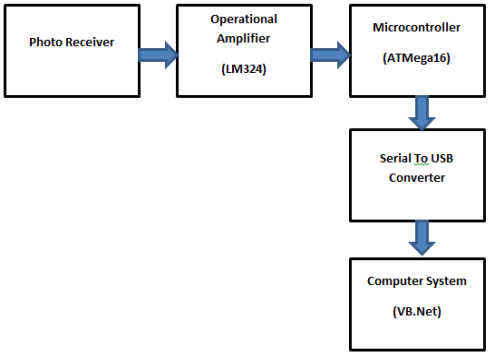
II. WORKING PRINCIPLE OF LI-FI SYSTEM

Li-Fi system worked on very simple principle as it uses already available light waves for data transmission. Light emitter is used at one side i.e. an LED transmitter, and a photo detector (light sensor) is used at another side.

The diagram below shows transmitter section consists of computer software application developed using VB.Net and for data transmission via microcontroller using USB to serial communication system, which will be decoded into digital data by the ATMega16 Microcontroller and again encode into digital bits transmission through LED bulb. [11]



Transmitter Section



Receiver Section

Figure 1: Basic Block diagram of Li-Fi System

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Similarly, at the receiver section a photodiode is attached with the system for the purpose of digital light detection, further the received signals will be amplified by the operational amplifier (LM324) for sending to the ATMega16 Microcontroller via serial transmission. The microcontroller attached at the receiver end will decoded into original format and display in on the LCD screen (16×2) and parallel it will transmit its data to the other computer system via usb to serial medium. Receiver section software application is also developed using VB.Net.

III. HARDWARE DESIGN OF A SYSTEM

The main objective is to develop a prototype using off the shelf electronic devices and establish a successful connection for the transmission of digital data which will result a working Li-Fi system. In order to achieve this goal, a PCB is designed using PCB Artist 4.0. Programming of Microcontroller (ATMega16) is done in AVR Studio_4 and a USB Programmer (as shown in figure 8) is plugged to transfer program into Microcontroller. A number of connection sockets that can be wired as LED, LCD (16×2), Motor Driver(L293D) etc using 9-V battery.

The major components are given below.

- ATMega16 Microcontroller
- Photodiode
- LCD-16x2 Display
- Motor Driver L293D
- DC Battery
- LM324 Op-amp
- Voltage Regulator
- USB to TTL Converter
- LED Bulb

a) ATMega16 Microcontroller: ATMega16 is an 8-bit high performance microcontroller from the Atmel's Mega AVR family. Atmega16 is a 40 pin microcontroller. It has a 16 KB programmable flash memory, static RAM of 1 KB and EEPROM of 512 Bytes. [4]

b) Photodiode: A photodiode is a semiconductor device, converts light into an electrical current.

c) LCD-16x2 Display: It is a display module & can be find in a wide range of applications. A 16x2 LCD display is very basic module and commonly used in various circuits and devices. A 16x2 LCD means it can display 16 characters per line & there are 2 such lines. [3]

d) Motor Driver L293D: L293D is a dual H-bridge motor driver IC. It acts as current amplifiers since they take a low-current control signal & provide a higher-current signal. The higher current signal is used to drive the motors. [5]

e) LM324 Op-amp: LM324 is a 14 pin IC consists of four independent operational amplifiers mounted in a single package. Op-amps are high gain electronic voltage amplifier with differential input & a single-ended output. [1]

f) Voltage Regulator: It is an electronic circuit which provides a stable DC voltage inspite of the variation in load current, temperature & the AC line voltage. [10]

*g) USB to TTL Converter:*The USB TTL Serial cables are a range of USB to serial converter cables which provide connectivity between USB and serial UART interfaces. It is available in 5V, 3.3V or user specified signal levels with various connector interfaces. [9]

A. Transmitter Hardware Design

The task of transmitter is to transmit digital data into visible light. An LED has relatively linear relation between current and light intensity hence it is most suitable component which can be used in transmitter. In Figure 2, schematic is shown to give an overview of the transmitter. The PCB for Transmitter end is designed using the following steps:

- The transmitter PCB design is done by converting the circuit's schematic diagram into a PCB layout. The software used for PCB design is PCB Artist 4.0.
- After completing the designing of PCB layout, the printout of circuit board is taken out on a glossy paper.
- Then the fiber plate is cut for the circuit board.
- After this, the PCB print is transferred onto the fiber plate.
- Next step is to solder & mount components shown in figure 4.

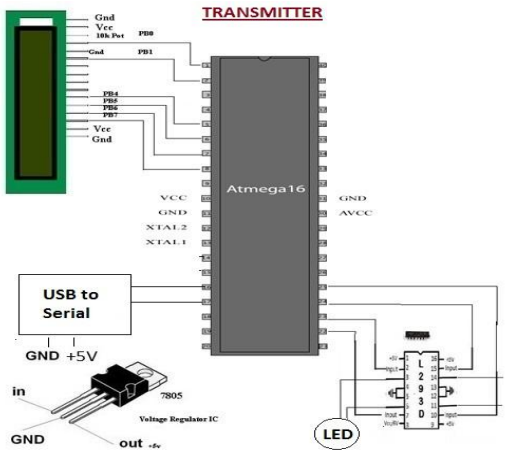

Figure 2: Schematic of Li-Fi Transmitter

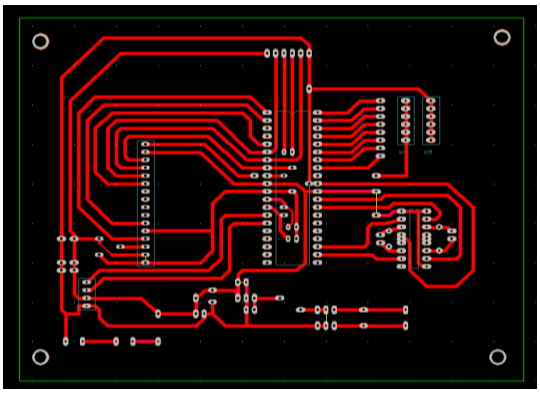

Figure 3: Transmitter design using PCB Atrist 4.0

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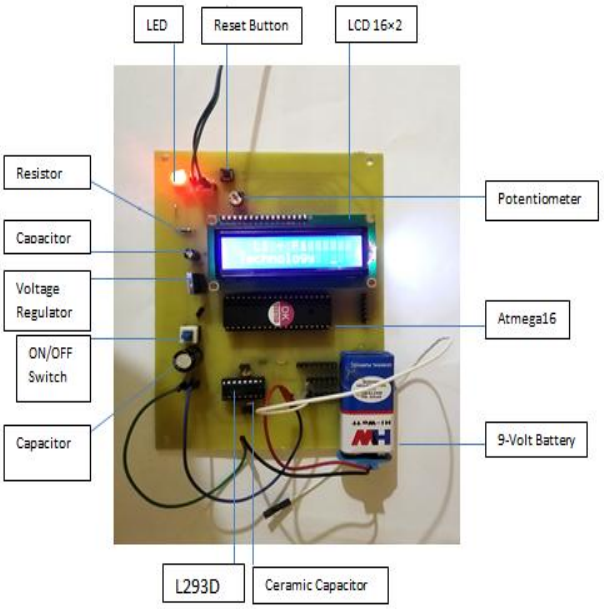

Figure 4: Components Soldered on Transmitter PCB

The transmitter receives a signal from the computer using USB cable, and this signal controls the transistor which open and close the power supply to the LED. The LED voltage levels can be noted that both 5v & 12v supply can be used in the transmitter for powering the LED but for the cause of simplicity 5v supply is preferred for low power operation.

B. Receiver Hardware Design

The task of receiver is to detect digital light and send it to the LM324 Op-amp for further amplification. Then input the signal to ATMega16 Microcontroller via serial transmission. The PCB for Receiver end is designed using the following steps:

- The receiver PCB design is done by converting the circuit's schematic diagram into a PCB layout. The software used for PCB design is PCB Artist 4.0.
- After completing the designing of PCB layout, the printout of circuit board is taken out on a glossy paper.
- Then the fiber plate is cut for the circuit board.
- After this, the PCB print is transferred onto the fiber plate.
- Next step is to solder & mount components shown in Figure 7.

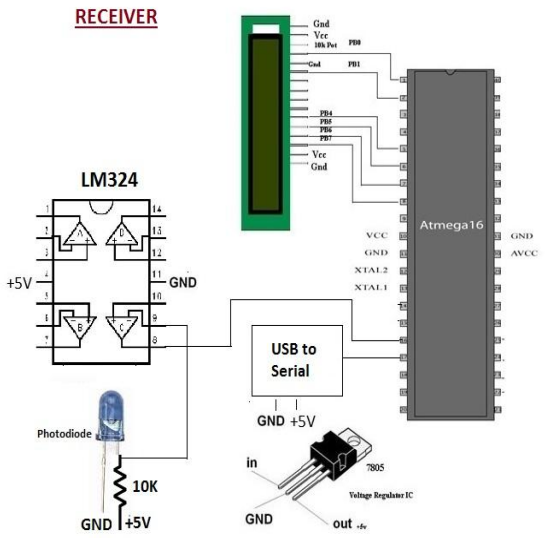

Figure 5: Schematic of Li-Fi Receiver

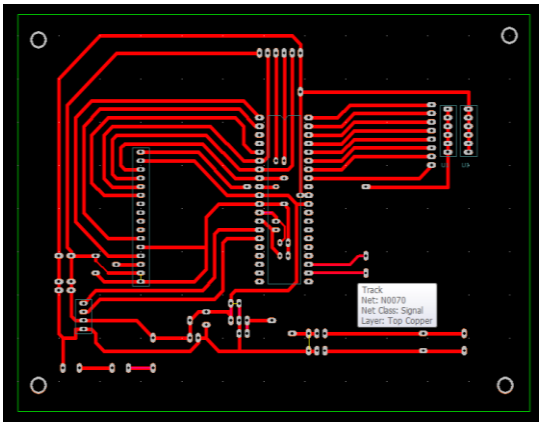

Figure 6: Receiver design using PCB Atrist 4.0

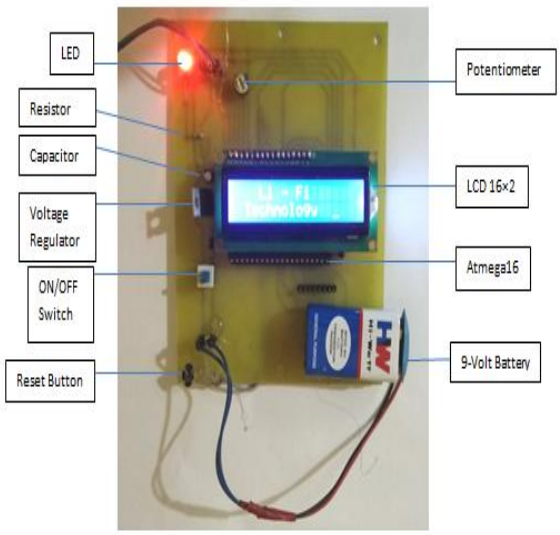

Figure 7: Components Soldered on Receiver PCB

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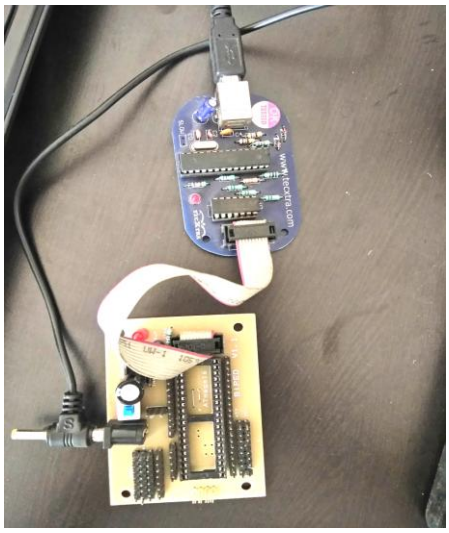

Figure 8: USB Programmer (STK500V2)

At the receiver end a photodiode is attached with the system for digital light detection, further it will be amplified by the operational amplifier for sending to the microcontroller via serial transmission. The microcontroller attached at the receiver end will decode the received signal to original format and display in on the LCD screen simultaneously it will transmit its data to the other computer system via USB to serial medium.

IV. Results

In this section, a summary of the design choices done during the research work and the achieved results are shown in the picture below.

From the figure 9, it is observed that the PCB is powered on with the help of 9-V battery which is connected to the transmitter and ON/OFF switch is put on in order to make the transmitter functional. As soon controller will receive character from the computer User Interface, it will be processed and displayed on LCD (16×2) screen in parallel it will transmit via LED to the receiver end. The receiver will receive the digital signal and amplified it by the use of operational amplifier which will directly transmit to the microcontroller for decoding into original data format and display on the LCD screen.

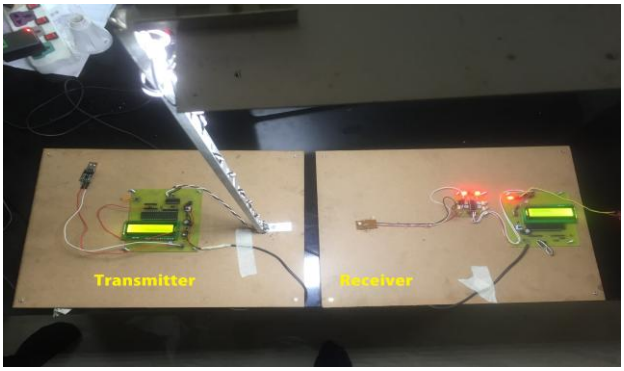

Figure 9: Complete Model for data transmission

V. Conclusion

In this research paper the working model of Transmitter & Receiver for transmission of text data is successfully completed. The PCB layout is sketched using PCB Artist 4.0 tool. The ATMega16 Microcontroller programming is done in AVR Studio_4 environment with Embedded C. After ensuring the successful transmission of data string, 2D image transmission will be done in near future.

Abbreviations

Li-Fi: Light Fidelity
VLC: Visible Light Communication
LED: Light Emitting Diodes
OP-AMP: Operational Amplifier
PCB: Printed Circuit Board
RISC: Reduced Instruction Set Computing
EEPROM: Electrically Erasable Programmable Read Only Memory
LCD: Liquid Crystal Display
RF: Radio Frequency
Gbps: Gigabit per Second
USB: Universal Serial Bus

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