March - April 2020
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Communication System based on VLC using Mobile Application

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Abstract:
The Visible Light Communication (VLC) is leading technology, with benefits of secure data communication, high energy efficiency, high data rate, long life and safe wireless communication. Moreover, it depends on fast switching of LEDs and the modulation of the lights waves. In this paper we offer an easy to execute and low cost VLC-based indoor system. The system is formed by LEDs which behave as a transmitter and a receiver interface connected to a mobile via Bluetooth, where a visual application runs. Moreover, LEDs are used not only for communication but also for lighting of indoor environment. Our approach reveals its advantages as globally consistent, low-cost, easy installation and it retains the potential applications using Visible Light Communication. This paper emphasizes on dimming and data transmission feature of VLC for indoor environment.

Keywords: *Visible light communication, LED (Light Emitting Diode) light, Bluetooth, Photodiode, LED driver.*

I. INTRODUCTION

The Visible Light Communication (VLC) is an emerging technology of optical communication that uses visible light between 400 THz and 800 THz to transmit the information. It was introduced by Professor Harald Haas during his TED Global Talk [1]. It consists more benefits in contrast to RF (radio frequency) signal, such as low cost, high data rate, safe and secure data communication [2]. Global positioning system (GPS) or the RF (mobile) signal does not work properly in indoor environments due to reduction of signal caused by building material [3]. Moreover, visible light communication has better performance network for indoor application using light emitting diode (LED) lamps.

Nowadays indoor environments use Wi-Fi inside their homes and offices. Hence, we restore it with cheaper and more efficient VLC [4]. It will save lot of energy and keep environment greenery. Indoor environment uses SSL lamp based on visible LEDs are more energy-efficient and longer lasting as contrast to incandescent lamps. LED has numerous beneficial features such as long life, fast switching, low power consumption, tolerance to humidity, low cost, small size and low heat radiation etc.[5]. Visible light communication employs LEDs which not only used for illumination but also used in data transmission [6]. It provides communication features such as highly secure, low cost, low power consumption, high bandwidth, and no health risk etc. due to these features, there has been a growing interest in research in VLC system.

In the visible light communication, LEDs are very popular due to its fast switching feature. They can be switched on and off at very high speed which result to less flickering effect. Human eye cannot perceive faster switching rate [7]. The frequency and brightness of the light is important at which data get modulates. The transmission data rate will depend on how fast LEDs are ON and OFF. The resulting data rate should be more than 10kbps. VLC has disadvantages such as if high power LED is not use then information can be lost. If light signal is block by obstacle then communication can be stopped. LED light is affected by sunlight which overlaps

March - April 2020
ISSN: 0193-4120 Page No. 2164 - 2170

with light rays. Hence, it is recommended that VLC transmission be indoors.

A VLC system consist two basic components which is shown in figure 1. The first component is LED equipped with controller unit for converting user data into light signal and the second component is photo detector for receiving light signal.

Fig.1. Visible Light Communication

The controller unit encodes user data and spread it through LED at rapid speeds. The photo-detector converts light signal into electrical signal, which in turn decoded into data stream at the end of device.

The rest of this paper is structured as follows: Segment II is about the system overview of visible light communication. Segment III is about hardware implementation. Segment IV presents software development. Segment V is about experimental result. Section VI presents limitation of VLC. Finally, the conclusion is drawn in section VII.

II. System Overview

The proposed system consist transmission and revive module which shown in figure 2. At the transmitting side, LED transmitter is composed of 4 LEDs, which has been driven by PWM LED driver according to the data pattern provided by user. LEDs are ON and OFF at very high speed which is not visible by naked human eye, where LED transmitters can be used as illumination device which widely utilized for indoors in the future. The main purpose of LED is to supply illumination without affecting data communication. The driver circuit controls the current passes through the LED when LED is in illumination phase and light can be modulated as per user data using driver circuit, when LED is in communication phase.

At the receiving side, PIN photodiode (PD) is used to detect the light signals and converts it into electrical signal. These electrical signals are amplified by transimpedance amplifier (TIA). For further demodulated and digitized via PIC controller. The digitized data will be transferred to mobile application (SSP App) via Bluetooth device. The responsivity of the PD is typically around 5mW/cm2 for a 940-nm input light, and the gain of is 100dBΩ. The received power can be calculated using relative position between the LED and photodiode.

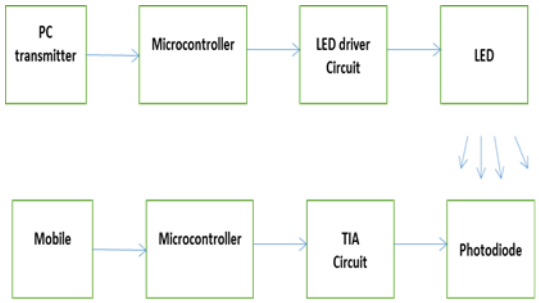

Fig.2. Visible light communication overview

III. Hardware Implementation

In this project we are transmitting user data from PC to microcontroller receives the characters in eight bits as per the ASCII Table. The modulated output signal of microcontroller is used to drive the LED via LED driver which powers the LED at very high speed as per stated by modulated output signal. Also, with the help of microcontroller we can see current status on LCD.

At receiving interface, photodiode is used to detect light signal and convert it into electrical signal. High pass filter is used to generate noise free signal which has been amplified and converted into usable voltage

by using transimpedance (TIA). Such amplified signal fed as an input to microcontroller (PIC18F452), which decodes the data and display on LCD. Microcontroller also sends the data to mobile application via Bluetooth.

A. TRANSMITTER MODE:

The transmitter module is composed of the following components: power supply circuit, PIC18F452, USB TX-MCU, PWM driver and light emitting diode (LED). The hardware implementation of transmitter module is shown in figure 3.

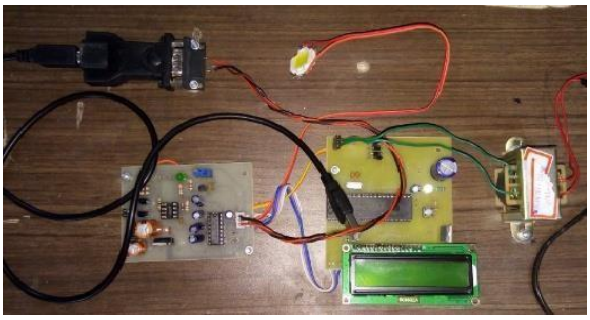

Fig.3. Transmitter module

1. Power Supply: The power supply is composed of the voltage regulator, passive components and bridge rectifier. It converts AC input into DC input and sends to the respective devices. The voltage regulator 7805 regulates the voltage level in the circuit.

2. USB to UART CONVERT: Computer accepts the user information and converts it into ASCII form respectively. This information is transmitted through UART to MAX232. The result of UART provides serial information. The voltage levels between RS232 logic levels and microcontroller is synchronized by using MAX232 which act as buffer circuit for microcontroller, where RS232 is communication cable which usually used for transmitting and receiving serial data between computer and microcontroller.

3. Micro-controller PIC18F452: In this VLC system, we are working with PIC18F452 microcontroller which used to store incoming data and send it to LED driver to drive the LED. The stored data also viewed on LCD panel.

4. *LED Driver:* It uses as a shunt switch in parallel to the LED string. LED driver provide both VLC data transmission using VPPM and illumination. The driver circuit is specified by lumen measurement for various dimming levels. It also controls current flowing through the LEDs. It is designed for output current 350mA and helps the data of PWM dimming level encoded in PPM scheme for VLC application.

5. *Modulated LED:* The main role of a LED is to generate light output to supply illumination. LEDs are widely used in advertising, automotive headlamps, medical devices, traffic signals, and camera flashes. LED has a distinct property to light on and off very rapidly. The data can be transmitted by lighting LED ON and OFF at ultra- high speed. LED has two basic characteristic as luminous intensity defines brightness of an LED and transmitted optical power specifies the total energy radiated from an LED. These characteristic defines the range of data communication. In the future, modulated LED transmitters are utilized in large scale for indoor communication and illumination.

B. RECEIVER MODULE:

The receiver module is composed of photodiode receiver, PIC18F452 microcontroller, High-Pass Filter, transimpedance amplifier (TIA) and Bluetooth. The hardware implementation of receiver module is shown in figure 4.

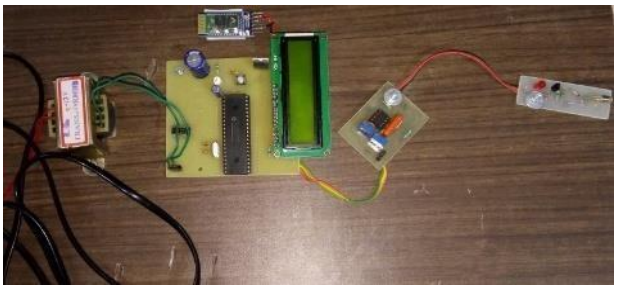

Fig.4. Receiver module

1. Photodiode Receiver: Photodiode- based receiver circuit is made to analyze pattern and strength of the light signal, where photodiode is used to detect invisible information of LEDs. Photodiode is detector which detects the lights signal and transforms it into electronic signal. The important specification is response time. If response time is less than 10ns then photodiode can be reacted faster to each data bit which has been transmitted. It means photodiode can support to the faster transmission rate with shorter response time. The longer response time will cause higher chance of error in data. Another important feature is wavelength range which should be larger for picking selected LEDs light.

Table-I: Photodiode Requirements

Category	**Desirable**	**Undesirable**
Wavelength Range	***erence of 700 nm or more***	***rence of 300 nm or less***
Response Time	***< 10 ns***	***>100ns***
Field of Vision	***> 30°***	***< 10°***
Price	***Less than $0.50***	***More than $1***

2. High-Pass Filter: It is used to eliminate noise from the output signal of photodiode. High pass filter is used before transimpedance (TIA) circuit to create a clean signal. If filter is not uses then noise will be amplified along with signal. Resistors and Capacitors are used to design the high-pass filter.

3. Transimpedance Amplifier (TIA): It is current to voltage converter. It can be used to amplify the current output of photodiodes to utilizable voltage. With the help of TIA low power signal converted into high power signal.

4. Bluetooth: HC-05 module is an easy-to-use Bluetooth SPP (Serial Port Protocol) module. It is designed for wireless serial connection. The line between the Bluetooth module TX pin and the microcontroller RX pin can be linked directly because the 3.3V signal from the Bluetooth is enough to be accepted as a high logic at the microcontroller.

IV. Software Development

The software development consist Hyper Terminal, MPLAB IDE V8.6 and Proteus 8 Professional.

A. Hyper Terminal:

It is communications software designated for PC. It is easy to configure RS232 terminal and easy for use. It is user interface software where user can type data in the Hyper Terminal in the form of text up to 1000 characters. It provides data frame to the microcontroller and also support non-standard baud rate.

B. MP LAB IDE v8.6:

It is a software program developed by Microchip Technology. It is run on PC to develop embedded applications for Microchip microcontrollers. It is also called an Integrated Development Environment, programming and debugging of Microchip 8-bit PIC and 16-bit PIC24. This software is easy to understand and also provide single integrated environment to develop code for embedded microcontrollers. For this project we used embedded C language to write code. The software consists data buffer, data framing for synchronization, data conversion from ASCII into binary bit stream and data modulation. Software is tested for any errors or warnings and finally the code must be dumped into the microcontrollers via a loader.

Algorithm for the design as follows:

1. Start
2. Initialize the I/O and serial port
3. Check for serial data
    a. if, correct go to step4
    b. if not correct then go to step 3.
4. Display on LCD
5. Send it
6. End

March - April 2020
ISSN: 0193-4120 Page No. 2164 - 2170

V. PROTEUS 8 PROFESSIONAL

Proteus is a Virtual System Modeling (VSM) which consists animated components and circuit simulation. It is easy to use due to GUI interface. Moreover, it can be used to design Print Circuit Board (PCB). Proteus has many features to generate both analogue and digital result. This is the perfect tool for engineers to test their microcontroller designs before constructing a physical prototype in real time.

VI. EXPERIMENTAL RESULTS

The proposed VLC-based system was implemented on PCB. The distance between LED and photodiode is 1m. Data from the LEDs is read out on mobile via SPP software.

Input data at transmitter side:
The snapshot shows the input data on Hyper Terminal which help for user interface by setting the baud rate at 1200bps and PWM input signal on oscilloscope which is used for dimming the LED. PWM signals are modulated by the user data. Also PWM scaling is ranges from 0%- 100% by adjusting the duty cycle.

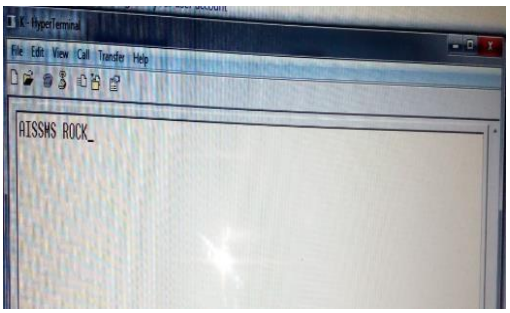

Fig.5.Output data on Hyper Terminal

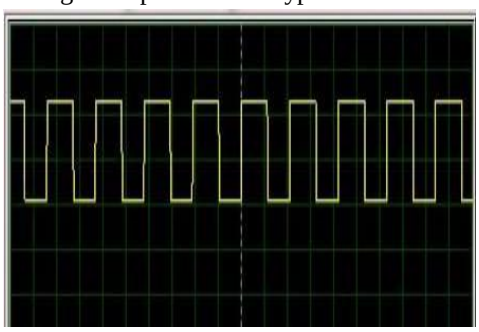

Fig.6. PWM signal on oscilloscope Output data at receiver side

The LCD displays the output data. Also Bluetooth module to ensure its connectivity to a smart phone and displays the output data on Bluetooth application which install in andriod mobile, so that without use of laptop the values can be displayed.

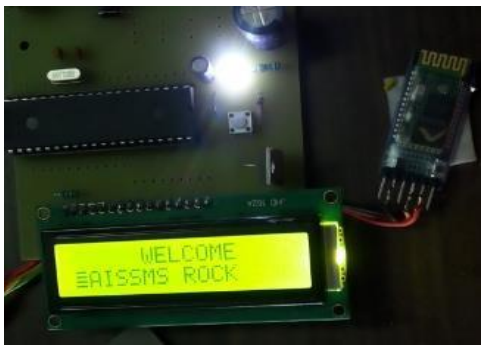

Fig.7. Data on LCD display

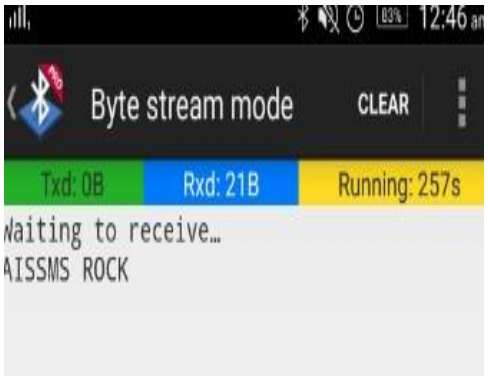

Fig.8. Data on Bluetooth serial terminal

VII. LIMITATION OF PROPOSED SYSTEM

1. Data communication may get block due to obstacle, as it require direct Line of sight between both communication devices.
2. Other light sources (e.g. sun light, bulbs and opaque materials) may cause interference in data communication.

3. The proposed system is restricted to short-range communication.

VIII. CONCLUSION

March - April 2020
ISSN: 0193-4120 Page No. 2164 - 2170

VLC is ideal for small distance. In proposed system, illumination and data transmission are major things. We discussed about those requirements and showed the example of design. We knew that the system made communication and lighting possible The VLC technology has grown significantly during last few years. It has a great importance especially for indoor applications. A person can utilize lights available at home for communication without disruption.

This method overcomes errors during maximum transmission rate in existing system and it is more efficient. This means that we must use existing infrastructure as much as possible.

IX. Acknowledgement

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