Data transmission using Li-Fi technology

ShabanaParveen M[1], Siddarthan K[2],Vignesh T[3], Ajay Krishnaa A R[4]

Department of Electronics and Communication Engineering,
Sri Sairam Engineering College, West Tambaram, India.

***Abstract*—Continuous improvements in wireless communication systems, e.g. 3G, 4G, etc.., require higher bandwidth and due to the lack of sufficient Radio Frequency spectrum, we should adopt a wireless system which will support wide bandwidth. So the new technology of Li-Fi came into the aid. Light fidelity (Li-Fi) is a new short range optical wireless communication technology which provides data transmission like text, audio, video by using Light-Emitting Diodes (LEDs) to transmit data depending on light illumination properties.It uses the visible light spectrum which is 10,000 times larger than the entire radio frequency spectrum [1]. In this technology, LEDs are used to transmit data in the visible light spectrum. Lasers can also be used instead of LED but it requires proper alignment between the transmitter and receiver. This technology can be compared with that of Wi-Fi and offers advantages like increased accessible spectrum, efficiency, security, low latency and much higher speed. Communication is achieved by switching LED lights or laser on and off at a data speed higher than what is perceptible to the human eye.This concept promises to solve issues such as the shortage of radio-frequency bandwidth and boot out the disadvantages of Wi-Fi. Li-Fi is the upcoming and on growing technology acting as competent for various other developing and already invented technologies. Hence the future applications of the Li-Fi can be predicted and extended to different platforms and various walks of human life.**

Keywords – Visible light communication, Li-Fi, LED, file transmission, UART

I. Introduction

Visible light communication is the term given to an optical wireless communication system that conveys information by modulating light that is visible to the human eye. Lasers and LEDs are the main components in a visible light communication system. The primary aim of our project is to transmit a video file from one computer to another computer through wireless optical medium using modulation of LEDs. A microcontroller, namely, Arduino Uno is used at both transmitting and receiving computers. The communication between Arduino Uno and computer is through Universal Asynchronous Receiver Transmitter (UART). The data from the transmitting computer is initially converted into an array of 0s and 1s and sent to Arduino Uno. In the Arduino, the bit stream is modified and encrypted. The resulting bit stream is used to modulate an LED attached to it. The modulation technique used is amplitude modulation. At the receiver end, the amplitude modulated signal is detected using a photodiode. The photodiode signal is amplified and digitized using a comparator. The digitized signal is send to Arduino Uno at the receiving end, where decryption of the signal is done. The encryption and decryption process is known only to the transmitting and receiving pair. The decrypted signal is sent to the receiving computer in the form of bit stream. An application is developed using Visual Studio to send the data from the transmitting computer to the Arduino Uno through the necessary COM port. Similarly another application is developed to receive the data at the receiving computer through the necessary COM port and store the data in a specific location in the computer.

II. Transmiitter

The transmitter section consists of an Arduino Uno, LED and an LED driver circuit and a power supply circuit to power the components.

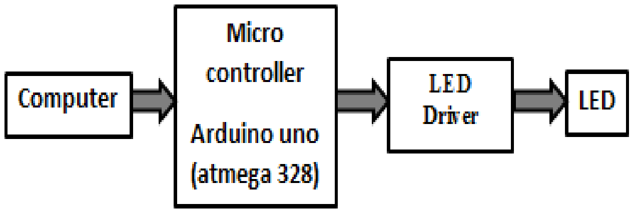


Fig. 1 Block diagram of transmitter section

Arduino Uno consists of a microcontroller, atmega328. The Arduino Uno has 14 digital input/output pins of which 6 can be used as PWM outputs, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack and a reset button.It is connected it to a computer with a USB cable or power it with an AC-to-DC adapter or battery. In our project we used an adaptor to power the board. The LED we used is a 12 Volt LED. Brightness of about 500 lumens is achieved at 12 Volt supply in the presence of ambient light. In the dark environment if further increases due to the absence of surrounding light. LED is powered by an AC to DC adaptor. The LED driver circuit consists of a transistor which acts as a switch. It is used to switch the LED on and off. The transistor used is 2N4401 NPN high frequency switching transistor operating in common emitter mode. The control signal from the Arduino Uno is connected to the base of the transistor. The LED is connected to the collector terminal of the transistor. When the transistor is on, it operates in saturation region and when the transistor is off, it is in cut off region.

III. Receiver

The receiver section consist of a photodiode, amplifier circuit, comparator circuit and an Arduino Uno

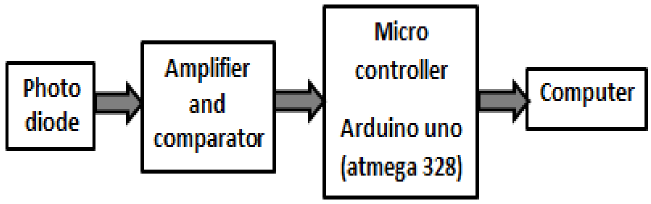


Fig. 2Block diagram of receiver section

A photodiode is used to detect the presence of light. The photodiode used is an avalanche photodiode. It is in reverse biased condition. When light is incident on the photodiode, the incident photons generate electrons resulting in a current flow through the photodiode resulting in a voltage across a resistor connected in series with the photodiode. The voltage value is very less to be given to the next stage. Hence it is amplified using an operational amplifier in non-inverting mode. The gain is set using the resistors to make the output of the amplifier lie in the desired range. The amplified signal is then digitized using a comparator. The comparator used in LM324. A threshold is set using a voltage divider circuit in the inverting terminal. The input is given to the non-inverting terminal. The output of the comparator will be 5 volts if the input is greater than the threshold value. The output will be 0 volts if the input is less than the threshold value. Thus a bit stream is generated. The bit stream will be sent to Arduino Uno, where the bit stream is decrypted and the original bit stream is obtained. The bit stream is sent to computer through UART.

III. Visual Basic Application

A visual basic application is required for transmission of data between the ArduinoUno and the computer both at the transmitting end and receiving end. In case of text transmission, it can be done with the help of serial monitor in Arduino Uno. But for the transmission of a file, special software is required. The application at the transmitting section allows the user to select the COM port to which the Arduino Uno is connected. The location of the file to be transmitted can be selected by clicking on the open file button. Once the required file is selected, the size of the file in bytes is displayed automatically in the File Size box.

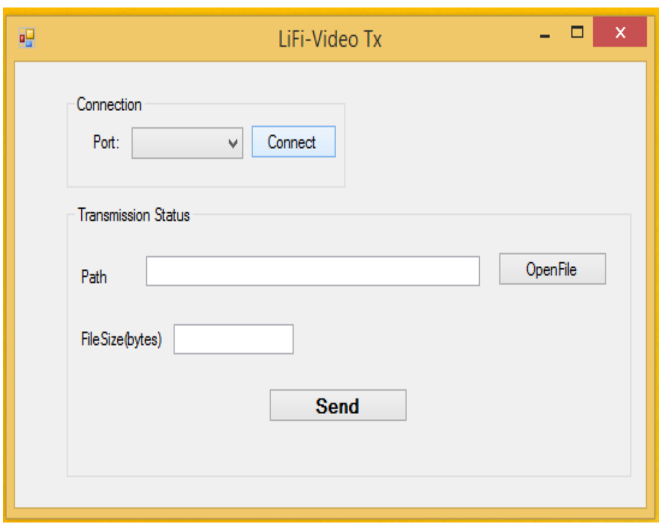


Fig. 3Application to transmit a file

In the receiver computer a similar application is used which is used to receive the file and store it in a particular location. In the dialog box, the COM port to which the Arduino Uno is connected can be selected. The file will be stored in a default location specified within the program.

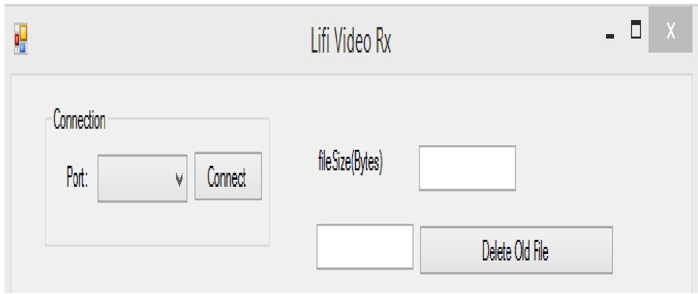


Fig. 4Application to receive a file

When the send button is pressed at the transmitting computer, the file size in the receiving computer starts to increase. When the transmission is complete, the file size in the transmitting computer and the receiving computer will be same in case of successful transmission. If the file size in the receiving computer is smaller than that of transmitting computer then it indicates loss of data.

IV. Encryption And Decryption

The bit stream in the transmitter is grouped into 8 bit size frames. Encryption of data is achieved by changing the position of the bits in the frame. Hence the bits are transmitted in a particular order rather than the original order. At the receiver end, the Arduino Uno is programmed such that the received bit stream is rearranged to obtain the original bit stream. If D represent the data bits in original order and E represent the encrypted bits, then the relation between the original and encrypted bits is represented as,

E0 -> D3
E1 -> D2
E2 -> D1
E3 -> D0
E4 -> D7
E5 -> D6
E6 -> D5
E7 -> D4

Fig. 5 Mapping encrypted bits with original bits

Consider a bit stream 10110010. It is stored in an array first. Then the encryption is applied to this array of bits and it is converted to encrypted data. The reverse process is done at the receiver side so that the original bit stream is obtained.

1	0	1	1	0	0	1	0
D0	D1	D2	D3	D4	D5	D6	D7

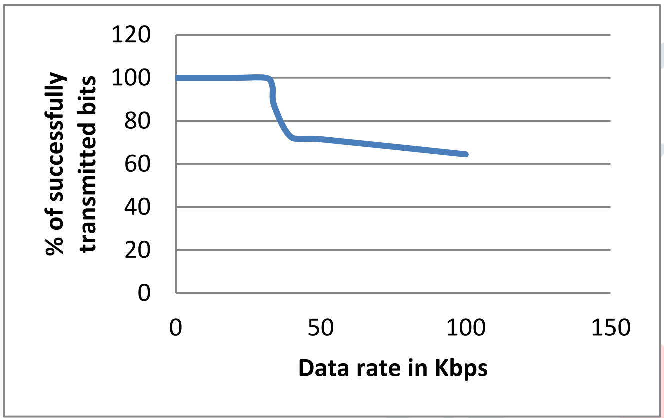
Fig. 6 Original bit stream

1	1	0	1	0	1	0	0
E0	E1	E2	E3	E4	E5	E6	E7

Fig. 7 Encrypted bit stream

V. Working And Results

Initially text is transmitted from serial monitor in one computer to another. Text was transmitted at a data rate of 9600 bits per second at a distance of about 5 metres with a very less error. However error is introduced when external light of very high illumination is present. File transmission was successfully done using the application at a data rate of 9600 bits per second at a distance of 5 metres. Data was transmitted at different data rates and the percentage of successfully transmitted bits was found.



It was found that there was 100% successful transmission at a rate below 30Kbps. Various types of files such as a word document, video file and image files were transmitted successfully. When the light path was interrupted during the transmission, there was a decrease in the received bytes displayed in the dialog box and the file was corrupted and cannot be opened. It was found that as frequency increases, there was a significant increase in error. But as the distance increases, there was little or no error as long as the illumination of the LED light was high.

VI. ChallengesAnd Future Scope

One of the primary challenges of Li-Fi technology is the light of sight between the transmitting LED and the receiving photodiode. As the result shows whenever the line of sight is disturbed there was a loss of data. To overcome this, an error detection mechanism with acknowledgment can be added to this system. One of the simple error detection mechanisms is using parity bit. A parity bit can be added to the 8 bit data at the transmitter Arduino Uno. It can be either odd parity or even parity. At the receiving end, the parity is checked. If there is no error, then the receiver can send acknowledgment to the sender through another channel. The sender can send the next packet only if it receives the acknowledgment. If there is no acknowledgement for a particular time, then the sender retransmits the previous packet.In this way bidirectional transmission of data with acknowledgment and error detection mechanism is possible.

VII. Conclusion

The Visible Light Communication technology has gained substantial interest due to its potential of offering high data rates, high security, no RF interference and lower energy consumption. Li-Fi can be used for indoor communication as an alternate to Wi-Fi. For the purpose of long distances lasers can be used however it requires temperature compensation circuit and proper alignment of transmitter and receiver due to low divergence of the laser beam. Various techniques has to be adopted to eliminate the errors that occur due to artificial lights in the indoors thus reducing the bit error rate.

VIII. References

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