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Li-Fi Based High Speed and Secured Data Transfer using MATLAB

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Abstract: - Li-Fi is one of the wireless technologies which uses visible light for communication. The objective of this paper is to objectify the methodologies to transmit and receive three types of data using Li-Fi: Audio, Text and Image between two devices. The information to be transmitted is converted in to binary data using embedded MATLAB algorithm. LASER diode is utilized as a Li-Fi transmitter and solar panel is utilized as a Li-Fi receiver. The data to be transmitted in Li-Fi is encoded in several bit-streams by flickers of the LED which vary at high-speed and the received bit-streams are decoded by photo detectors such as LDR or Solar panel. It is accomplished by binary transmission of data through LED, where '0' is the LED in 'OFF-state' and '1' is the LED in 'ON-state'. Transmitted data is compressed to increase the speed of transmission using Compression algorithms.

Key Words: - Li-Fi, LED (Light Emitting Diode), Visible Light Communication, Photo Detector

I. INTRODUCTION

Li-Fi is the abbreviated form of Light Fidelity. The region of operation of Li-Fi is the visible light spectrum which has the range 400 nm to 750 nm in the electromagnetic spectrum. Li-Fi uses visible light to transmit and receive data. Any light source is viable for visible light communication. In this project, LASER diode is used as the source for Li-Fi data communication. The current supply to the source is varied at a very fast rate based on the binary data fed to the microcontroller. Thus, the intensity of the LED is changed at a high speed which the human eye cannot perceive. This change in intensity causes the source to flicker at a very high rate. If the source is "OFF", the photo detector perceives it as a binary zero and if the source is "ON", the photo detector perceives it as a binary one. Li-Fi data rate is increased by using an array of LEDs/LASER diodes, where each LED/LASER diode transmits a different data stream which provides parallel data transmission.

The concept of Li-Fi was first demonstrated by Professor Harald Haas who utilized a table lamp with a LED bulb as the source for transmitting video of blooming flower which was projected on the screen. After this demonstration, the Li-Fi consortium was formed by the industries and company groups for promoting high-speed optical wireless systems. In 2012, VLC technology was exhibited by using Li-Fi Consortium. In coming years, large number of devices that support Li-Fi will hit the market.

II. LITERATURE SURVEY

The paper [1] proposes the audio communication from microcontroller to speaker using LED as Li-Fi transmitter and avalanche photo detector as Li-Fi receiver. The audio to be transmitted is processed by PIC16 microcontroller which is programmed using Embedded C. It lacks real time high speed data transfer implementation of Li-Fi. It also lacks transmission and reception of image and text files using Li-Fi.

The paper [2] proposes the basic Li-Fi working using LED as Li-Fi transmitter and photo transistor as Li-Fi receiver with 8051 microcontrollers for data processing which is programmed using Embedded C and Keil Microvision software. Transmitter and Receiver circuit designing is carried out using Proteus 7.0 software. It fails in the real time high speed data transfer implementation of Li-Fi. It lacks image, audio, and video transmission using Li-Fi.

The paper [3] proposes the transmission and reception of data and image between Li-Fi transmitter and Li-Fi receiver. It has utilized OFDM modulation and provides a brief comparison of the efficiency of different modulation techniques such as, OOK, PWM and, PPM with respect to OFDM. It lacks text, audio and video transmission using Li-Fi system.

The paper [4] proposes the designing of a Li-Fi transmitter and receiver circuit and evaluation of its performance. The effect of natural and ambient noise on Li-Fi communication

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is recorded by varying the distance between the systems. It does not provide the real time implementation of high speed data transfer of Li-Fi. It lacks practical implementation of Li-Fi system and image, audio, video and text communication.

The paper [5] proposes audio and video transmission using white LED as Li-Fi transmitter and photo detector as Li-Fi receiver with PIC microcontroller for data processing. It also discusses the factors affecting Li-Fi communication such as number of LED arrays and luminous intensity of LEDs. It lacks real time high speed data transfer implementation in Li-Fi.

The paper [6] proposes binary data and audio transmission using LED/LASER as Li-Fi transmitter and solar panel as Li-Fi receiver with Arduino microcontroller for processing of data which is programmed using Arduino IDE. It compares the efficiency of data transmission of LED and LASER as transmitter. It lacks real time high speed data transfer implementation of Li-Fi. It also lacks transmission and reception of image, text, and video files using Li-Fi.

The paper [7] proposes data and audio transmission using white LED as Li-Fi transmitter and photo transistor as Li-Fi receiver with AT89S52 microcontroller. It also provides a brief comparison regarding Li-Fi and Wi-Fi networks and about the advantages and applications associated with Li-Fi. It lacks real time high speed data transfer implementation of Li-Fi. It also lacks transmission and reception of image and video files using Li-Fi.

III. PROPOSED MODEL

The below block diagram provides a brief overview on the construction and working principle of the proposed Li-Fi system which is to be designed.

A. Working Principle

The main principle of Li-Fi communication system is - if the LED is turned ON, binary ONE will be transmitted and if LED is turned OFF, binary ZERO will be transmitted. Li-Fi is a VLC (visible light communication) system which uses LED as the source of light. Li-Fi uses normal LEDs to transfer the data which is received by a photo detector which can be a LDR or Solar panel or Photo diode etc. and this increases the data rate up to 224 Gigabits/sec.

The essential devices of this system are the bright light emitting diodes and the photo detector circuits.

The LED flickers due to the large and subtle variation in the current so that the data is transmitted at a very high speed.

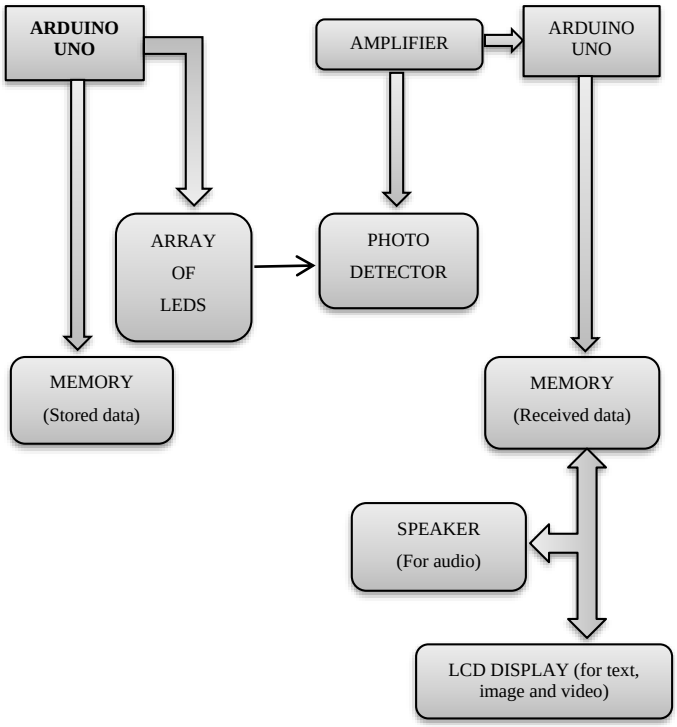


Fig 1: Block diagram of proposed Li-Fi Module.

The flickering rate of LEDs is varied so that the information encoded can be obtained in different sets of 0's and 1's but the human eye cannot recognize these variations and the diode appears to be emitting light of stable intensity.

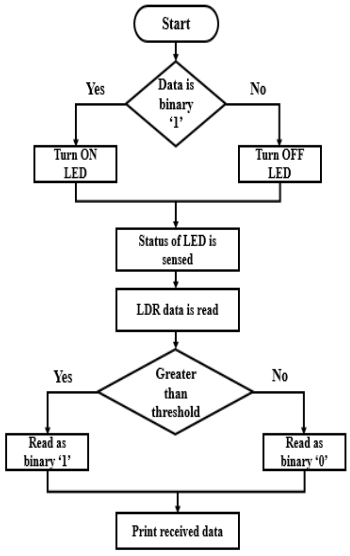


Fig.2. Flowchart of Li-Fi communication

The high speed flickering is perceived by the photo detector circuit and the received data is sent to the microcontroller for

processing. The received data is reconstructed to obtain the originally sent file.

By utilizing compression algorithms in the microcontroller using MATLAB, the data to be transmitted can be compressed to reduce the overall size of the data and increase the speed of transmission and reception.

Different compression algorithms have been utilized for files of different formats such as text, image, audio and video files.

IV. OBJECTIVES AND METHODOLOGIES

The objectives and methodologies of the paper is outlined as below:

A. To implement and design Li-Fi transmitter and receiver systems to successfully transmit and receive data

Methodology:

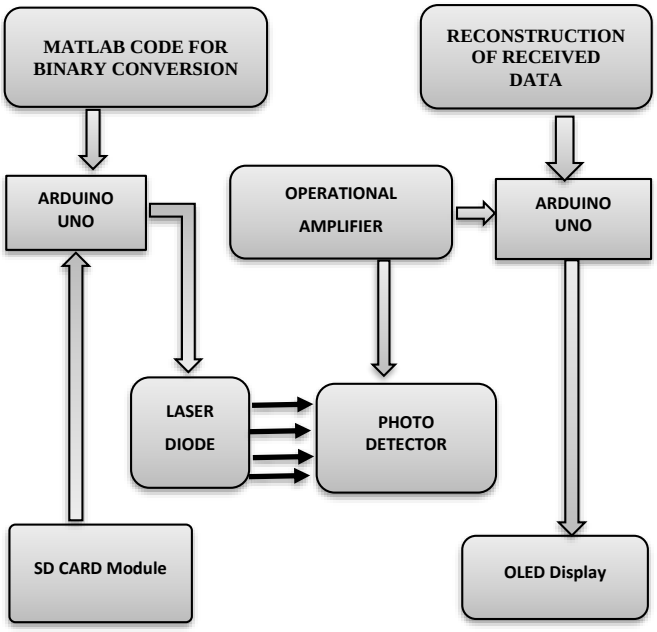


Fig 3: Block diagram of Li-Fi Communication system

Transmitter Section:

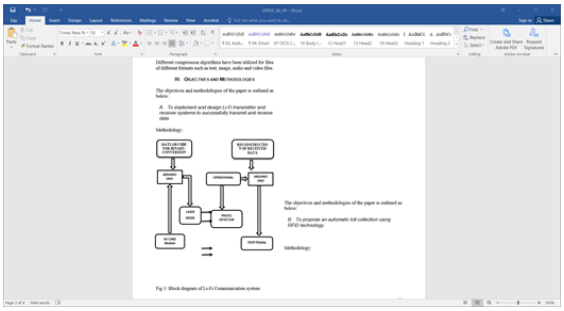
1. The input file to be transmitted is stored in the memory of microcontroller. During transmission, the selected file is compressed to reduce the data size.
2. The compression algorithms are loaded on to the microcontroller using MATLAB.
3. The compressed file is converted into binary data by the embedded MATLAB algorithm.
4. For a Li-Fi transmitter, LASER diode is used which provides a unidirectional ray of light and thus, prevents scattering.
5. The microcontroller serves as a driver which drives the LASER diode to produce flickers of light corresponding to the pattern of the data to be transmitted.
6. Every moment at which the diode is OFF is considered as binary '0' and when the diode is ON, it is considered as binary '1'.

Receiver Section:

1. The transmitted data travels through the propagating medium (air) in the form of visible light.
2. The transmitted light is received by a photo transistor which acts as the Li-Fi receiver.
3. This property is utilized in the project to read the transmitted data accurately by estimating the output voltage of solar panel.
4. For the reception of complete data, the receiver and transmitter must be placed in Line of Sight (LoS) i.e. both transmitter and receiver must be facing each other without any obstacles between them.
5. The output of the phototransistor is amplified by the operational amplifier.
6. The amplified voltage is fed to the microcontroller. It processes the data and reconstructs the original transmitted data.
7. The reconstructed data is decompressed to retrieve the original file in the memory of the microcontroller.
8. The output file can be observed in the OLED display (for text and image files) and through the speaker (audio files).

B. To compress text files using Huffman coding algorithm and transmit & receive the compressed data using Li-Fi transmitter and receiver

Methodology:



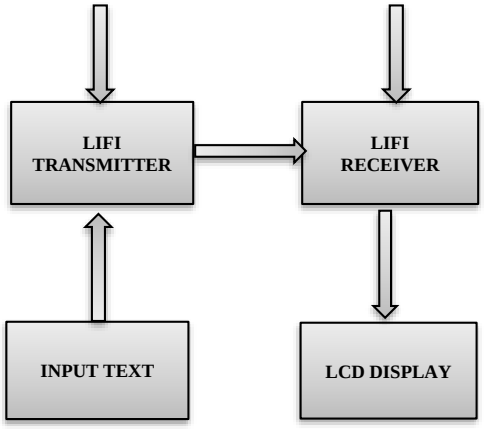


Fig.4. Block Diagram of Text Communication

1. Huffman coding algorithm is the most efficient algorithm for compression of text.

2. The compression and decompression speed of Huffman coding is very high when compared with arithmetic coding and LZW coding algorithms.

3. Static Huffman is chosen over adaptive Huffman coding because it is simpler and requires less compression time.

4. Static Huffman coding assigns codes of variable length to symbols based on their frequency of occurrences in the given text file.

5. Symbols with lower frequency are encoded using more number of bits and symbols with higher frequency are encoded using less number of bits.

6. The text file to be transmitted is processed to find the relative frequencies of its constituent characters.

7. The coding process generates a binary tree called the Huffman code tree, with branches labelled with bits (0 and 1).

8. For each distinct character, it creates a one-node binary tree containing the character and its frequency as its priority. The one-node binary trees are inserted in a priority queue in increasing order of their frequency.

9. The Huffman tree or the character code word pairs must be sent along with the compressed information to enable the receiver decode the message.

10. The Arduino microcontroller changes the intensity of the LASER diode according to the compressed binary data.

11. Each character in the text file is converted into binary data equivalent to its ASCII value.

12. If binary '1' is transmitted, the LASER is turned ON and if binary '0' is transmitted, the LASER is turned OFF.

13. The status of the LASER is read by photo transistor and the sensor data is received by the controller.

14. If the voltage across the photo transistor is greater than the threshold, it is read as binary '1'.

15. If voltage across photo transistor is lesser than the threshold, it is read as binary '0'.

16. The received data is displayed in the OLED display

C. To successfully transmit and receive image files using Li-Fi communication system.

Methodology:

1. The input image is converted into a bitmap file in which the intensity in each pixel is coded as a byte of data.

2. Many such pixels form an array of bytes in which each array element represents a pixel in the image.

3. Image2cpp is a simple tool which converts image to a bitmap file.

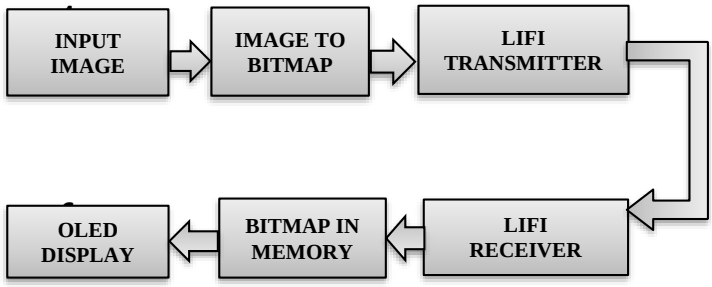


Fig 5: Block Diagram of Image Communication

4. This array is loaded on to the SD card module and is processed by the controller.
5. The controller varies the output of LASER diode according to the binary data.
6. The transmitted binary data is received by the phototransistor and by reading the respective voltage changes across the transistor, the controller predicts the original data.
7. The predicted data is reformed into an array or a bitmap file.
8. This bitmap file is loaded into the memory of the OLED display module.
9. The transmitted image will be displayed in the OLED display based on the data stored.

D. Design of audio amplifier to transmit & receive the audio file using Li-Fi transmitter and receiver.

Methodology:

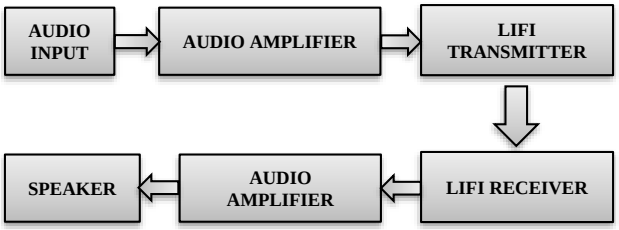


Fig 6: Block Diagram of Audio Communication

1. The incoming audio signal is converted into an electrical signal using the microphone.

2. The output electrical signal from microphone is typically around the amplitude of 200mV.

3. An audio amplifier is designed to amplify the incoming electrical signal to the required voltage range so that it can drive the LASER diode.

4. LASER diode is used as the Li-Fi transmitter due to its directivity and intensity.

5. The LASER diode is turned ON and OFF based on the variations in the amplified signal.

6. The solar panel at the receiver side accurately records the variation in the intensity of LASER diode.

7. The voltage generated from the solar panel is amplified by the audio amplifier at the receiver so that it can drive the speaker.

8. The transmitted audio signal can be listened through the speaker.

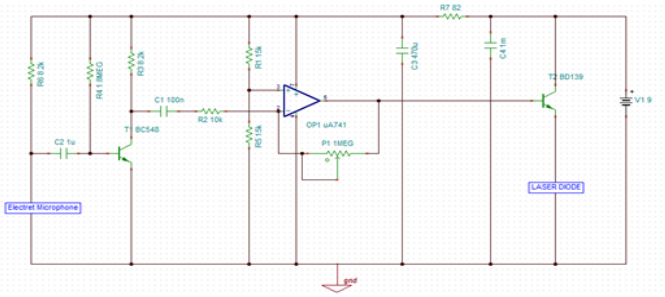


Fig 7: Audio Transmitter

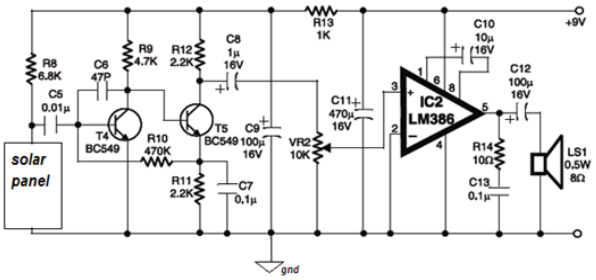


Fig 8: Audio Receiver

V. RESULTS

By utilizing the given methodologies, Li-Fi can be used to transmit and receive text, image, audio and even video files. The software code needed for the transmission and reception of these files varies for the chosen file format. But the underlying principle behind the communication of these files remains the same.

By implementing the Li-Fi transmitter using a simple LED and the Li-Fi receiver using a simple LDR, we have achieved successful transmission and reception of a string of characters which is nothing but a text file. The Arduino IDE software tool has been used to program the Arduino Uno board for transmission and reception of the text file. Fig 8 shows the received string of characters on the serial monitor using Li-Fi.

Successful Image transmission and reception has been performed using Li-Fi. The Transmitted image is shown in fig 10 and the received image is shown in fig 9. The image received is almost identical to the transmitted image.

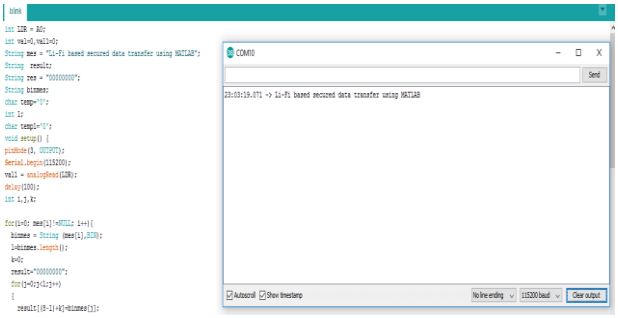


Fig 8: Serial monitor showing successful reception of text

Fig 9: Received Image

Fig 10: Transmitted Image

VI. CONCLUSION

The aim of this paper is to develop a simple and low-cost prototype module that can be used to transmit any type of multimedia files using LED/LASER. For the successful transmission of data signal, the receiver's sensor should be in the range of LED/LASER and in Line of Sight (LOS). Now-a-days LED's are used everywhere thus can be used in communication process. Thus, Li-Fi technology is leading the indoor communication. The prominent use of LED for communication is due to its fast switching property. It also uses VLC which does not involve the hazardous effects of radio waves like Wi-Fi and Bluetooth. As this is eco-friendly, a sustainable environment can be achieved which is free from hazardous radio waves.

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