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DATA TRANSFIRMATION THROUGH VISIBLE LIGHT COMMUNICATION (VLC) /LI-FI USING WIRELESS COMMUNICATION TECHNOLOGY

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Abstract

The Radio Frequency (RF) communication suffers from high latency and interface issues.
Beside with it, a separate setup for transmission and reception of Radio Frequency (RF) waves is require for Radio Frequency communication (RF). In order to overcoming the said limitations, a preferred communication technique is required such as Visible Light Communication (VLC) which has higher bandwidth and immunity to interference from electromagnetic sources. The modernization in the field of solid-state lighting primes to the replacement of florescent lamps by Light Emitting Diodes (LEDs) which further encourages the usage of Visible Light Communication (VLC). This research work represents a survey of the potential architecture, applications, modulation techniques, standardization, and research challenges in visible light Communication (VLC). In this project we have developed an Arduino based visible light communication system which is often called Li-Fi. As opposed to traditional Wireless Fidelity (Wi-Fi) technology, Light Fidelity (Li-Fi) technology uses visible light spectrum to transmit data quickly and securely.

Keywords-*Visible Light Communications (VLC), Light Emitting Diodes (LEDs), Infrared (IR), Radio Frequency (RF)*

I. INTRODUCTION

Technology is advancing enough to influence our daily lives. Living without technology is nearly impossible. This new era of technology facilitates us to communicate, transfer data, process information and make advancements in our daily life. The fifth generation (5G) of cellular networks has recently undergone considerable and rigorous development, which has resulted in its widespread deployment across much of the globe. One of the issues that needs to be resolved as part of this implementation is the skip-zone problem, which arises when things like trees, people, animals, and cars block the transmission of signals[10].The concept of Wi-fi grown found by many people for good reason.

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Wi-Fi has nearly taken over every aspect of human civilization, from the workplace and home to essential governmental services like ICT. People seem to still be unfamiliar with a similar type of notion known as LiFi because of this extreme dependence on Wi-Fi, despite the fact that it has been available for many years and is still widely regarded as the greatest wireless communication medium.One intriguing new technology is VLC. Applying it to practically every application is therefore appealing. As a result, the VLC idea has received a lot of attention lately [11].

This Project is based on Data Transfer and Communication. As we all are very much familiar with the existing technologies of data transfer and communication, data can be transferred through various mediums such as signals, Wires, and even by the pulses of light through fiber medium made of glass, which is the fastest way of communication yet known. The technology revolution rapidly facilitates us with faster and cheaper ways of data transfer and communication. The Visible Light Communication is one of the recently discovered technology for data transferring and communication, "Visible Light Communication (VLC)" / Li-Fi (Light Fidelity). This project is as simple as "the apple fell on the newton's head" and behind that simple act, lies the most fascinating theories. Light is known as the fastest source of illumination that can travel through the empty space. Today the technological advancement makes it possible to transfer data with the help of visible light. Nearly 10 years ago the experiment was done by: "Dr Harald Hass", that a visible light (LED) can transfers data faster than the fiber optic and Wi-Fi. A Light Emitting Diode, which illuminates with the flow of current, not only brightens the space but it can also be used to transfers every kind of data instead of using signals and wires [5].

In this Project we will use a new way of transmitting data, which will not only change the old mediums of communication (wires & signals) but will also benefit us in faster data streams and communication. In this project, we will work on a "Visible Light Communication", a process of transferring data. We will not only transmit audio signals but text data as well with the help of LED lights.

II. RELATED WORK

The history of wireless communication, which is based on electromagnetic waves, dates back to Alexander Graham Bell's invention of the photo phone in the late 19th century. Because it was the first communication gadget utilized wirelessly. Bell's idea used sunlight to transmit information [1]. Because smart phones carry more than 600TB of data each day [2,] the standard radio wave spectrum is no longer adequate in today's technologically advanced world. The fourth stage of the mobile trade revolution, according to the [3], is the new generation of wireless communications, which permits connectivity between various machines and items around the globe [3]. Now a day's internet has become an integral part of the life; individuals are in search of Wi-Fi hot spots. Therefore this advanced development of today's communication system enables the need of Light Emitting Diodes (LEDs).The transmission of data is much faster and reliable through Light Emitting Diodes in comparison of transmission of data through Wi Fi [4].Principal investigator Erik Holbert explains that the prototype light fixtures developed in the Kennedy Space Center's Swamp Works are primarily made with readily available off-the-shelf hardware. He points to the one circuit board in the light fixture that was developed at the Florida spaceport. It might develop into a really useful technology in the future, he continued, if we can make it profitable. VLC is a pretty fundamental idea, claims principal investigator Erik Holbert, Ph.D. The technique merely offers a wireless network that transmits data through copper cables and light rather than radio waves [6].

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The technology and applications are also being worked on by the Fraunhofer Heinrich Hertz Institute in Berlin. In order to replace the current radio-based Wi-Fi solution, an optical broadband system was implemented in May at a location near Lake Constance in Germany using VLC technology. Although the initiative is in its early phases, the institute already seems confident in the effectiveness of the system [7].

Analysts at Disney show up to be less hesitant almost extrapolating conclusions approximately Li-Fi and its potential employments. Disney Research's remote investigate bunch submitted a paper at a workshop at MobiCom 2015, held in Paris, France, that among other things set how Li-Fi may offer assistance fuel IoT [8].

III. MEHTOD AND TECHNIQUES(PLAN OF WORK)

A. What is Wi-Fi?

Wireless Fidelity (Wi-Fi) is a wireless networking technology that uses radio waves to enable wireless network connections, provide Internet access, and transmit data. It's one of the very common approaches to allow handlers to access the network without a physical connection between devices. Once radio frequency (RF) current is applied to the antenna, it creates an electromagnetic field that broadcasts throughout each room, creating an access point for users to connect to the network. These access points are accessible within the domain. To connect to an access point, the accessing device must have a wireless network adapter installed.

B. The Radio Spectrum

The radio spectrum is the portion of the electromagnetic spectrum with frequencies ranging from 3 Hz to 3,000 GHz. Waves emitted in this range of frequencies, called radio waves, are of great importance, especially in telecommunications, and are susceptible to interference occurring at different frequencies, such as radio fidelity within this spectrum. For this reason, the generation and transmission of radio waves is strictly regulated by national laws in coordination with the International Telecommunications Union (ITU).

C. Visible Light communication system

On the other conclusion of the range, Light Constancy (LiFi) could be a modern innovation that transmits information utilizing Unmistakable Light Communication (VLC) innovation or maybe of radio waves. Solid-state lighting (SSL) such as Driven bulbs are utilized in LiFi to transmit information and give internet or remote arrange network. This can be finished by balancing the light transmitted by the transmitter and gotten by a photodiode (the receiver).The signals from the transmitter are at that point changed over into valuable information designs that the conclusion client may effectively ingest. Due to the nature of obvious light, LiFi associations are regularly obliged to the space where they are
advertised.

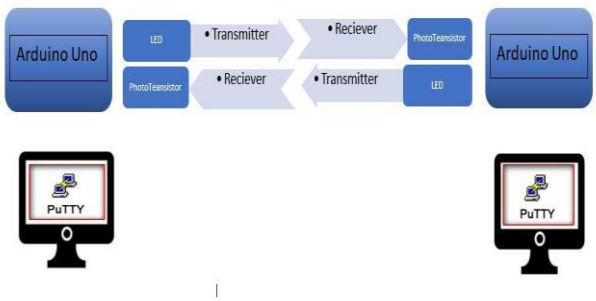

Figure 1: Block Diagram of VLC System

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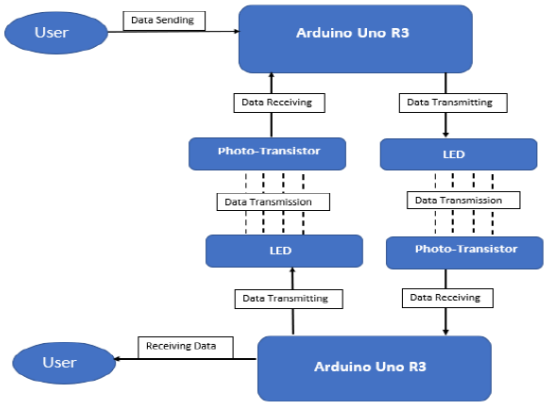

Figure 2: VLC Use case Diagram

D. The Visible Light Spectrum

Light constancy (LiFi) employments unmistakable light, not at all like radio waves. As the unmistakable light range is 10,000 times bigger than the whole radio range, LiFi has get to a broader extend of frequencies. Unmistakable light range covers frequencies from 430,000 to 770,000 GHz and colors from close bright to approach infrared. LiFi offers a wide run of points of interest. Its greatest advantage is its effectiveness. Clients of LiFi appreciate lower vitality costs due to its utilize of VLC innovation, which makes utilize of profoundly effective Driven bulbs. Moreover, they require as it were working Driven lights that are as of now accessible in most families and other foundations, permitting for considerable fetched reserve funds in terms of establishment. As a advance advantage of LiFi, light voyages at amazingly quick speeds, which permits LiFi associations to happen nearly right away. The result is quicker information transmission and web network - almost 100 times speedier than Wi-Fi.

IV. FRAMWORK AND IMPLEMENTAION OF VLC

A. Audio Transmission over Visible light

Figure 3 discuss the transmitter circuit diagram for sound input and Figure 4, show the Sound output diagram of proposed system. In this research work we have used a 9V Battery or any power source for LED, an Aux cable, 1 LED and some alligator clips. The connection is as follows, 1st battery's positive is directly connected to LED's positive terminal along with 100ohm transistor (optional), 2nd negative terminal of LED's is connected to the ground of Aux cable, 3rd Aux cable pin's top two portions (which are the for the left & right headphone because we did not cut the wire) is connected to battery's negative terminal (in case of 4 pin connection, the 2nd from the bottom is left free). 4th the other side of the Aux cable is plugged in to mobile phone or laptop for the audio source. This is our transmitting (input) side connection. Now to the receiving (output) side we have used a small solar panel, and a speaker. For the output connection we will simply connect the positive of the solar panel to top two portions of the speaker's Aux cable and negative of the solar panel to the ground of Aux pin of speakers, & provide the power source to the speakers as shown in the figure 3. In the last just place the solar panel near LED so it can see light & fetch audio from the visible light (Note: solar \\panel must be in the range of visible light otherwise it will not fetch extract data from the visible light) and now turn the audio from mobile on, if the steps are followed correctly, then you will hear the audio from the speakers.

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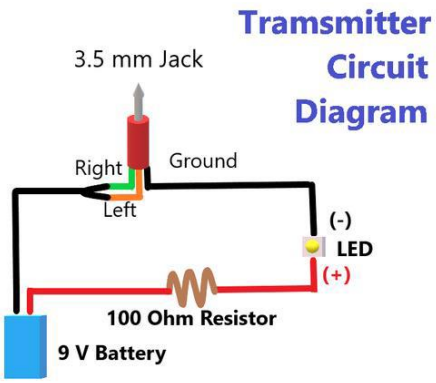

Figure 3: Sound Input Diagram

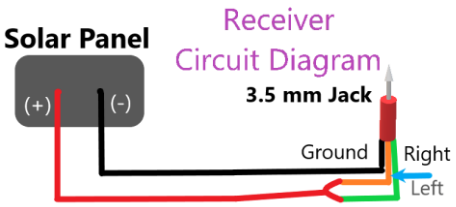

Figure 4: Sound Output Diagram

B. Pulse Modulation Technique Demo

In this demonstration, we triggered data stored in Arduino based on the light pulse duration. If the light pulse from the source is equal to 001 milli-second "Hi" message will be shown in the screen. & if the light pulse is 0001 milli-second then "Hello" will be printed. This is based on the flickering of an LED as shown in figure 5.

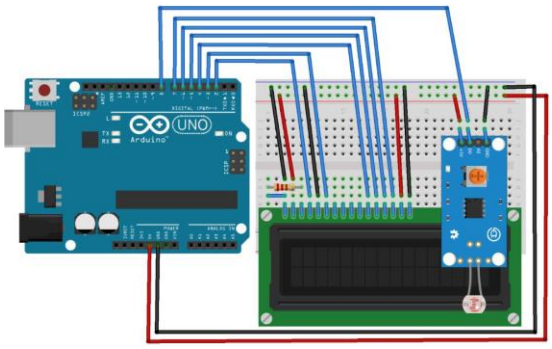

Figure 5: LDR Receiver Diagram

This is the receiver side connection. Where LDR (Light Dependent Resistor) module is used as a receiver, Arduino is programmed to operate as mediator or central device for both LDR & LCD, because Arduino receives data through LDR and shows the targeted data on the screen, as mentioned above [9]. On the transmitting side we just used an open-source flashlight application with the functionality of flashlight duration time setting. In this project the Arduino compares the signal received from the mobile application through LDR in time duration (since LDR is sensitive to light we turned off the room's lights and then we simply turned the

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flashlight on & off quickly just right above on the LDR, so it can get full light, and it showed the message “How are You?” stored in Arduino on the screen as shown in figure 6.

Figure 6: Proposed framework Demo

C. Two-way message communication

In our 3rd demonstration we have developed a simple serial communication system and replaced the source wires with the LED as source of medium for exchanging information. In which we have used 2 Arduino boards, 1 breadboard, 2 LEDs, 2 Photosensor, and some jumper wires. Both Arduinos are capable of transmit and receive data. Concept is always the same just the diagram has changed. In that case I will explain any one of them because both have same connections & functionalities. 1st we have uploaded the Serial-Communication program available in Arduino library in which we have declared pin 11 of Arduino as transmitting pin and pin number 10 as the receiving pin. In pin 11 the positive wire of LED is connected and 5V power is given. Negative of LED to the ground (negative). In pin 10 a Photosensor’s data pin called “do” pin is connected. 5V power is given to Photosensor & as usual negative pin to the ground as shown in figure 7.

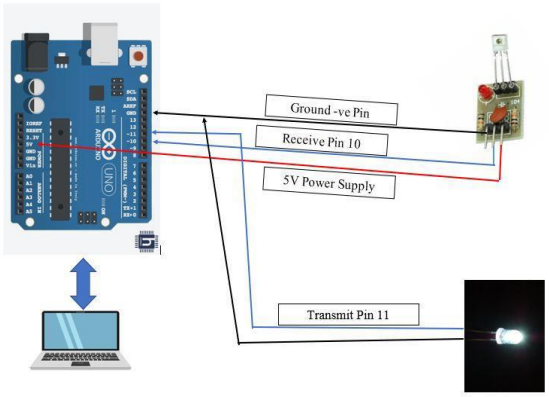

Figure 7: VLC Communication System

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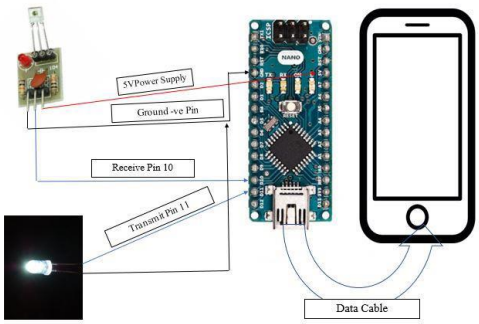

Figure 8: Proposed System

The figure 8 discuss the proposed system each of its phases are discussed below:

Serial Connection Phase: First, we have to create serial ports with the help of Putty or HyperTerminal, through which we will receive and send messages coming/going from USB Serial Ports.

Arduino Program Phase: 2nd program pre-written in Arduino library will take data from USB Serial Ports and Transfer it to the output pin (11 of Arduino), in which the positive wire of the LED is connected.

Transmitting: LED is our transmission medium, through which our data will be transmitted. When the LED blinks it means the data has been sent or in process. (LED flickers very fast that human eye cannot detect it blinking). The power supply is 5V.

Receiving: Photodetector is used to detect the blinking of LED and receive the data transmitted through light source. 1st Negative is connected to 5V power pin of Arduino and 2nd Negative is inserted in input pin (10 of Arduino), the Positive is left free and is not used but Positive pin of Photodetector must be in visible light of LED.

The program that we have used is the pre-written SoftwareSerialExample.ino code which is available in Arduino Library. Which is shown below in figure 9.

SoftwareSerialExample §

```
#include <SoftwareSerial.h>
SoftwareSerial mySerial(10, 11); // RX, TX
void setup() {
  // Open serial communications and wait for port to open:
  Serial.begin(9600);
  while (!Serial) {
    ; // wait for serial port to connect. Needed for native USB port only
  }
  Serial.println("Goodnight moon!");
  // set the data rate for the SoftwareSerial port
  mySerial.println("Hello, world?");
  mySerial.begin(9600);
}
void loop() { // run over and over
  if (mySerial.available()) {
    Serial.write(mySerial.read());
  }
  if (Serial.available()) {
    mySerial.write(Serial.read());
  }
}
```

Figure 9: Software Serial Example.ino

D. Serial Communication Application

We have used an open-source Serial Communication application which provides us with the capability to use mobile phones port as a serial Communication port, for data transfer.

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V. RESULTS AND DISCUSSION

This project is basically designed to show how we can transfer any kind of data with the help of visible light of LEDs. First a message (data) is generated from the serial application, sent from Software Serial to USB Port Serial using the Serial Communication Example.ino program available in Arduino library, Second Arduino sends data to TX (Transmitting) pin 11 in which the LED positive wire is connected, and the data goes through LED. The LED transmits data by flickering very fast that human eyes cannot see the blinking of LED. On the receiving side a Photodetector is connected in pin 10 of Arduino, which is our RX (Receiving) pin. From the pin 10, data is transferred from USB Serial Port to the Software Serial Port and "msg" is displayed on the Screen of software.

Application Interface

The Graphical user interface (GUI) of the proposed application has been used in this research work.

The proposed system is a fully functioning message communication system, can be used for any purpose almost by everyone. An open-source serial communication android application, available in google play store free of cost as shown in figure 11. We have covered the above-mentioned limitations and successfully transferred messages over the light using our mobile phones. The data processing is much faster in our system then any traditional communication system. But we do face other limitations like, we cannot send any image or video or any graphics like emojis over the serial transmission yet, this is because we have used an open-source application in our system which provides no functionality of such communication. Therefore, this system can be implemented as an emergency communication system during the times of crisis, or any natural disastrous situation. Although this is the most useful communication system in terms of emergency communication system. The first use of this system can be implemented in mountainous regions like Gilgit Baltistan, Murree, Azad Jammu & Kashmir, & other hilly regions of Pakistan where the signals freeze in chilly cold environment. This system can also be implemented for building-to-building communication, such as peer-to-peer connection.

VI. CONCLUSIONS & FUTURE WORK

The proposed work has been developed and implemented successfully. The results shows that how data (message & voice) can be transferred by using the intermediate source visible light of LEDs as medium of communication. The obvious light communication can ended up a compelling strategy for future communication due to the highlights of tall transmission capacity, and non-interference with the radio waves into electromagnetic touchy regions conjointly safe to wellbeing is well.

During implementation and testing, we found that the transferring of data is much faster as compared to the existing medium of communication. As compare to the analogous Wi-Fi, which uses radio frequency for communication Li-Fi is 250 times faster [10].Such frameworks have potential and can be brought into utilization at various situations and places such as Visible light ID system, Li-Fi, traffic communication system, and under-water communication. This research work can be continued in future for testing additional android application for

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better conversation such as sharing images, video, emoji and all the other features that a modern-day messenger possesses.

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REFERENCES

[1] Böcker, A., Hansson, V. E. D., Holgersson, P., Nolkrantz, J., & Severinson, A. (2015). An implementation of a visible light communication system based on LEDs. Bachelor thesis, Chalmers University of Technology-Gothenburg, Sweden.

[2] Siddique, I., Awan, M. Z., Khan, M. Y., & Mazhar, A. (2019). Li-Fi the next generation of wireless communication through visible light communication (VLC) technology. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 5(1), 30-37.

[3] Yuvaraju, M., Mansingh, P. B., & Sekar, G. (2021, February). A Li-Fi Based Collision Avoidance System For Vehicles Using Visible Light Communication. In 2021 7th International Conference on Electrical Energy Systems (ICEES) (pp. 114-116). IEEE.

[4] R.Mallika@Pandeeswari; "Survey of (LI-FI) Light Fidelity" ,2nd Year-IT, Department of Information Technology, Mepco Schlenk Engineering College

[International Conference on Emerging Trends in Applications of Computing (ICETAC 2K17) http://www.ijetjournal.org ISSN: 2395-1303]

[5] Spurr, K. (2014, January 14). How an LDR (Light Dependent Resistor) Works. Kitronik Ltd. https://kitronik.co.uk/blogs/resources/how-an-ldr-light-dependent-resistor works#:%7E:text=What%20is%20an%20LDR%20(Light,used%20in%20light%20se nsing%20circuits.

[6] Light-technology-being-developed-for-advanced-communications. (n.d.). Https://Www.Nasa.Gov. Retrieved April 30, 2021, from https://www.nasa.gov/feature/light-technology-being-developed-for-advanced-communications.

[7] Khan, L. U. (2017). Visible light communication: Applications, architecture, standardization and research challenges. Digital Communications and Networks, 3(2), 78-88.

[8] France, C. (n.d.). France bans wifi in nurseries. Retrieved April 11, 2021, from https://www.connexionfrance.com/French-news/France-bans-Wifi-in-nurseries

[9] Jin, X., Wang, L., Luo, T., & Du, W. (2013). Fine-grained access control for html5-based mobile applications in android. In *Proceedings of the 16th Information Security Conference (ISC)*.

[10] Aboagye, S., Ndjiongue, A. R., Ngatched, T. M., Dobre, O. A., & Poor, H. V. (2022). RIS-assisted visible light communication systems: A tutorial. IEEE Communications Surveys & Tutorials.

[11] Oyewobi, S. S., Djouani, K., & Kurien, A. M. (2022). Visible light communications for internet of things: Prospects and approaches, challenges, solutions and future directions. Technologies, 10(1), 28.