**AUDIO TRANSMISSION THROUGH LI-FI USING NODE MCU**

**PROJECT REPORT**

***Submitted By***

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***In partial fulfillment of the award of the degree of***

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**In**

**ELECTRONICS AND COMMUNICATION ENGINEERING**

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**I**

**BONAFIDE CERTIFICATE**

Certified that this project report **“AUDIO TRANSMISSION THROUGH LI-FI USING NODE MCU”** is the Bonafide work of **“VAISHNAVI V (201EC277), SOBIKA S K (201EC256) AND VINOTHINI R (201EC288)”** who carried out the project work under my supervision.

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Department of Electronics and Communication Department of Electronics and Communication Bannari Amman Institute of Technology Bannari Amman Institute of Technology

**Submitted for Project Viva Voce examination held on……………………**

**Internal Examiner 1 Internal Examiner 2**

**II**

**DECLARATION**

We affirm that the project work title **“AUDIO TRANSMISSION THROUGH LI FI USING NODE MCU”** being submitted in partial fulfillment for the award of the degree of **Bachelor of Engineering in Electronics and Communication Engineering** is the record of original work done by us under the guidance of **Dr . SAMPOORNAM K P**, Professor, Department of Electronics and Communication. It has not formed a part of any other project work(s) submitted for the award of any degree or diploma, either in this or any other university.

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**III**

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**IV**

**ABSTRACT**

In today's interconnected world, the proliferation of wireless devices accessing the internet continues to surge, leading to escalating network complexity and a strain on available wireless radio bandwidth. This surge also raises concerns about the potential for interference in radio frequencies, which can compromise the reliability and security of data transmission. However, Li

Fi technology offers a promising solution by leveraging Visible Light Communication (VLC) through light-emitting diodes (LED's) for data transmission. Li-Fi operates by using LED's as transmitters and photo-diodes as receivers, utilizing light waves to carry data instead of traditional radio frequencies. The use of light for data transmission not only enhances security but also mitigates concerns about radio frequency interference. Moreover, the rapid advancements in LED manufacturing have led to the development of highly efficient, durable, and long-lasting LEDs, making them suitable for both private lighting and data transmission purposes. The effectiveness of Li-Fi is further underscored by its ability to achieve data transmission rates of several gigabits per second (GBPS), surpassing many existing wireless technologies. Consequently, the implementation of Li-Fi technology holds immense potential for revolutionizing communication systems, particularly in environments where security, speed, and reliability are paramount. The design and implementation of Li-Fi audio transmission systems exemplify the innovative applications of this cutting-edge technology, offering a glimpse into the future of wireless communication. As research and development in Li-Fi continues to progress, the possibilities for its integration into various industries and everyday applications are limitless, paving the way for a more efficient and interconnected world.

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**IX**

**CHAPTER 1**

**INTRODUCTION**

A representation of sound is an audio signal. Frequencies in the audio range of 20 to 20000 Hz are used in audio signals. The mechanism by which audio signals are routed and processed is known as an audio transmission system. The audio signal was transmitted via microphones, and the signal was routed to a single output channel. Microphones will send and process audio signals, but the light in this article will function as a transmitter, transporting data.

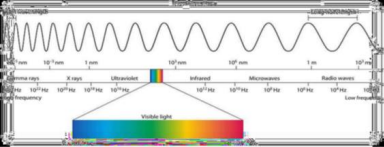
The acronym LI-FI refers to ‘Light-Fidelity’. Harald Hass, a German physicist, invented the phrase LI-FI. This is the next generation of the internet, in which data is sent using light as a medium. LI-FI is a novel and efficient kind of wireless Light based communication. LI-FI is a new and efficient wireless communication technology that sends data using light. It's the same light we use in our homes and offices, but with a few changes, it can convey data to all of our internet-connected devices. To transfer audio data, VISIBLE LIGHT COMMUNICATION (VLC) is employed, and LI-FI (Light Fidelity) technology has been developed. LI-FI is a one

of-a-kind method of sending data across small distances in a quick and effective manner. The operating principle of LI-FI is to communicate data in a standardized manner using the AM of the sunlight source. We can transfer data at speeds more than 10 Gbps with this method, and its operational frequency ranges from 400THz to 800THz.

It is a part of the IEEE standard IEEE 802.15.7. Wireless LI-FI technology in the future might attain data speed of up to 100Gbps. WI-FI is now used around the

**1**

world; but, because of its speed and security, LI-FI will supplant WI-FI in the future years. With the aid of the electromagnetic spectrum, high-speed data transfer utilizing LI-FI may be described. Because visible light has a frequency in the range of 430THz to 770 THz on the electromagnetic spectrum, a high number of bits may be sent over this bandwidth.

**Figure 1.1 Electromagnetic spectrum**

As a result, the rate inside the LI-FI will be greater, and faster speeds will be obtained more frequently. We can send many sorts of data over a Wi-Fi network utilizing LI FI. The main goal is to design a transmitter and receiver for audio using a LI-FI configuration. LI-FI isn't only about light and LEDs; it's a platform with a wide range of benefits and features. This LI- FI subject is about pulling the fiber out of fiber optics and transmitting data through an LED. This study provides an objective overview of LI-FI's operation, benefits, and applications. The goal of this article is to provide a method for data transfer that is both quicker and more secure.

The major goals of this project are to develop and build a LI-FI-based wireless data transmitter and receiver. VLC is used to convert audio files. The use of light as a carrier to send and receive audio data. The goal of this project is to create a data transmission system that is both quicker and more secure.LI-FI technology offers

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the following benefits: faster data transmission than WI-FI, easier and less expensive to implement, faster data transfer due to greater speed of light emitted by the laser, high security due to light restrictions, safe from electromagnetic interferences, cheap cost, portability. The data throughput for internet applications is higher, there is a

large lot of energy reduction in industry that utilizes LI-FI based equipment, and it runs on optical bands that are not hazardous like RF spectrum. As a result, the LI FI-based technology poses no health risks. This method has a wide range of uses Because operating rooms do not allow WI-FI because it emits dangerous signals, LI FI may be utilized in a variety of sectors, including hospital automation. Where the usage of radio spectrum is highly hazardous, LI-FI audio transmission is commonly used in petrochemical industry automation. Because WI-FI and many other forms of radiation are harmful to such vital places, LI-FI can be utilized in power plants. Localized advertising is frequently done by broadcasting over the LI-FI channel into smaller distances, and it may also be utilized in underwater systems for voice communications and device management. Secure networked medical equipment, patient accounts, and other information can all benefit from LI-FI. This system may be utilized in places such as workplaces, hotels, and other places that demand strong illumination. As a result, lasers and high-intensity LED lights may both be employed.

**1.1 SCOPE OF THE PROJECT:**

**1.1.1 OBJECTIVES:**

The project aims to develop a prototype system for audio transmission utilizing Li Fi technology. It involves implementing modulation and demodulation techniques to encode and decode audio signals for transmission via light waves. The integration of Node MCU with Li-Fi modules facilitates the establishment of communication

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between the transmitter and receiver components. Real-time audio transmission with low latency and reasonable audio quality is a primary goal of the project. Additionally, the investigation of potential applications and scenarios for

Li-Fi based audio communication, such as in home automation, audio streaming, and other IoT domains, will be explored. This endeavor seeks to demonstrate the feasibility and practicality of utilizing Li-Fi for audio transmission, opening avenues for innovative applications in various domains.

**1.1.2 CHALLENGES AND CONSIDERATIONS:**

Ambient light sources pose a risk to Li-Fi reliability, demanding careful interference mitigation strategies. Synchronization and error correction mechanisms are pivotal in preserving data integrity amidst Li-Fi transmissions. Efficient operation hinges on mindful power management of both Node MCU and Li-Fi modules, warranting optimization efforts. Compatibility and integration hurdles may emerge, necessitating meticulous coordination between hardware and software components for seamless functionality.

**1.1.3 FUTURE ENHANCEMENTS:**

The system will be fortified with encryption and security measures to safeguard transmitted audio data, ensuring confidentiality and integrity. Exploring multi-node Li-Fi systems offers potential for enhanced coverage and reliability, promising expanded applications and robust connectivity. Investigating bi-directional audio communication through Li-Fi technology paves the way for interactive applications, fostering immersive user experiences and diverse functionality. Additionally, evaluating scalability ensures readiness for larger deployments and commercial utilization, addressing future growth and widespread adoption considerations.

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**1.1.4 DOCUMENTATION AND PRESENTATION:** The project documentation will encompass the design, implementation, and testing phases, providing insights into the development process. A detailed presentation will showcase project objectives, methodologies, results, and potential applications, fostering understanding among stakeholders. Sharing outcomes through workshops, seminars, and technical publications will disseminate insights into Li-Fi's potential for audio transmission via Node MCU, stimulating further exploration in IoT and audio communication spheres.

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**CHAPTER 2**

**LITERATURE SURVEY**

1.Shmita Shetty (2016) conducted a comparative study of Li-Fi and Wi-Fi technologies. While Wi-Fi relies on radio waves for data transmission, Li-Fi utilizes light. This implies that the paper may explore the advantages of using Li-Fi for audio transmission using a Node MCU device. Li-Fi could offer several benefits for audio transmission: potentially experiencing less radio interference compared to Wi-Fi, resulting in clearer audio transmission, and potentially providing higher bandwidth, enabling the transmission of high-quality audio. However, it is crucial to acknowledge the limitations of Li-Fi, such as its typically shorter range compared to Wi-Fi and the necessity of a line of sight between the transmitter and receiver. [1] The paper likely commences with an introduction to Li-Fi and Wi-Fi, elucidating the fundamental principles, historical context, and applications of each technology. It proceeds with a review of prior research, discussing the strengths and weaknesses of both technologies and identifying gaps in the existing literature that the study aims to address. [1]The methodology section outlines the approach taken for the comparative analysis, detailing the parameters, equipment, and procedures utilized. The core of the paper involves a comparison of various aspects of Li-Fi and Wi-Fi, including speed, bandwidth, range, coverage, security, interference, energy efficiency, and cost. The findings of the analysis are presented and discussed, providing insights into the strengths and weaknesses of each technology. The paper concludes by summarizing the key findings and suggesting potential avenues for future research or practical applications[1].

2.Oliveira et al. (2016) titled [2]"Undergraduate Electronics Projects Based on the Design of an Optical Wireless Audio Transmission System" explores the development of such a system as a valuable educational tool for undergraduate electronics students. The authors begin by providing background information on optical wireless communication and its potential application in transmitting audio signals. They likely discuss the importance of practical, hands-on projects for students' learning and reference existing research on optical audio transmission systems, including challenges and opportunities. Next, the paper outlines the

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objectives, which likely involve describing the design, implementation, and educational value of the optical wireless audio transmission system. The methodology section details the design process, including components, circuit design, modulation techniques, and any simulations or experiments performed.

Following this, the paper dives into the system design itself, potentially presenting schematics, diagrams, and explanations of each component's function within the system. The authors then present the results of their experiments or simulations, such as audio quality, transmission range, and comparisons with existing wireless audio technologies. The educational benefits of the project for students are then explored. This section likely discusses how hands-on experience with designing and building the system enhances students' understanding of electronics concepts and prepares them for future careers in the field. Finally, the paper concludes by summarizing the key findings and potentially discussing future directions for research or improvements to the optical wireless audio transmission system[2].

3.SatyaJaswanth Badria & SaiHemanth Badri ( 2019 ) This paper explores Visible Light Communication (VLC) with Li-Fi technology to address the challenges of limited Radio Frequency (RF) resources. With increasing demand for faster data transmission, VLC, integrated into 5G, emerges as a solution. Focusing on audio and video transmissions, the goal is to design a real-time Li-Fi-based transmitter and receiver system. Testing under varying conditions like distance, intensity, and quality aims to verify performance. VLC offers advantages such as high data rates, traffic management, low power consumption, and cost-effectiveness. This research contributes insights for implementing audio transmission through Li-Fi using Node MCU, presenting an efficient and secure alternative in emerging technologies. With clogged radiowaves and limitations in bandwidth, data transmission is hitting a wall. Enter Li-Fi, a rising star shining bright with VLC (Visible Light Communication) technology. Li-Fi uses visible light for data transfer, promising ultra-fast speeds and enhanced security. That's why it's grabbing attention and even sneaking into 5G. This paper explores Li-Fi's potential for audio and video transmission by building a real-time system. We'll test performance under different conditions like distance, light intensity, and signal quality. Our goal? Design and test a Li-Fi setup for audio and video transfer under various scenarios. Why is VLC hot stuff? It boasts blazing fast data rates, sips power, and sets up cheap – perfect for future tech like 5G. What

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we learn: How Li-Fi transmits audio and video, its strengths and weaknesses. What we do: Build a simple Li-Fi setup for audio transmission with your Node MCU – a step towards future-proof communication! .In essence, this project dives into the exciting world of Li-Fi and takes a practical step towards harnessing its power for audio transmission[5].

4.R. Sakthi Prabha (2019) focuses on wireless sensor networks (WSNs) and securing them against malicious attacks, not directly on audio transmission. It proposes a system to identify problematic nodes that selectively drop data packets. While not directly related to Li-Fi and audio, it touches on network security, a crucial aspect of reliable data transmission.explores a reputation system coupled with adaptive detection mechanisms utilizing the AODV protocol to mitigate forward attacks in wireless sensor networks. While not directly related to audio transmission through Li-Fi using Node MCU, its insights into enhancing security and reliability in wireless networks could be valuable for your project. [6]Specifically, the paper discusses strategies to ensure robustness against malicious attacks, which could be relevant for safeguarding audio data transmission integrity in your Li-Fi setup. Incorporating reputation-based mechanisms and adaptive detection techniques may fortify your Node MCU-based system against potential threats, contributing to improved performance and reliability in audio transmission via Li-Fi[6].

5.Saranya et al. (2021) propose a system for transmitting audio data using Li-Fi technology, a form of Visible Light Communication (VLC). They highlight limitations of current wireless technologies like Bluetooth and Wi-Fi, such as cost, power consumption, and security concerns. Li-Fi, utilizing visible light for data transmission, is suggested as a potential solution. It offers advantages like wider bandwidth, enhanced security confined to the illuminated area, and use in restricted areas where radio waves are prohibited. However, challenges with Li-Fi are acknowledged, including the line-of-sight requirement and limited range. The authors developed a prototype for real-time audio transmission using commercially available Light Emitting Diodes (LEDs). Key findings include achieving real-time audio transmission at a distance of 2 feet with proper LED placement and concentration techniques, as well as simulations showing a connection between LED layout and light distribution within a room. While the current prototype has

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limitations in range, it demonstrates the feasibility of Li-Fi for audio transmission, indicating the need for further research to improve transmission distance and make Li-Fi a more practical solution for various applications. In essence, this research explores Li-Fi's potential for audio transmission. While the current prototype has a limited range, it demonstrates the concept's feasibility. Further research is necessary to improve transmission distance and make Li-Fi a more practical solution for various applications[9].

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**CHAPTER 3**

**OBJECTIVE AND METHODOLOGY**

**3.1 EXISTING SYSTEM:**

The LED on the transmitter will flash whenever a 3.5mm audio jack is attached to an audio source, such as a smartphone, but the intensity of the light will not change when the phone is switched off. As soon as we start listening to the audio, we'll notice that the intensity of the light changes frequently. When we turn up the volume on our phone, The intensity of the LED light varies at a pace that is quicker than the human eye can process. LED's have a wavelength range of 275 to 950nm, hence they will only reach a small distance. At the receiver end, a solar panel is installed that is so sensitive that it can detect slight changes in intensity and, as a result, the voltages at the solar panel's output vary. [2]As a result, when the LED hits the panel, the voltage varies depending on how bright the light is. The voltage from the solar panel is then routed into an amplifier, which amplifies the audio signal and outputs it through the speaker.

To get clear audio output, we can keep the LED at a maximum distance of 15-20 cm from the solar panel. Because LED's are inexpensive and widely available, this system can be implemented; nevertheless, the main disadvantage/drawback of employing LED's is that their range is limited, which necessitates a large solar panel area and greater wattage power. Data transmission requires a near or perfect line-of

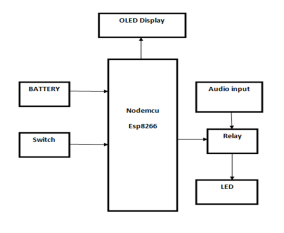
sight, which can be affected by LED, natural light, sunlight, and conventional electric light. As a result, in the suggested system of this research, laser light is used instead of LED.

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**3.2 PROPOSED SYSTEM:**

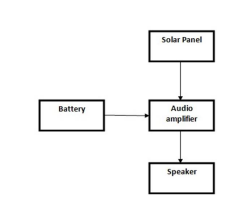
Visible light is a new technique of data transmission method. Li-Fi, data is transmitted by modulating the intensity of the light, which is then received by a Photo-sensitive detector. VLC, consists of a light source as a transmitter and detector as a receiver. Louder the voice, the glow of the LED will be more. [4]The receiver section interprets the incoming light which is detected using a solar panel and converts to the audible sound signal with the help of Speaker. Hence with Li-Fi this method is made sophisticated by using more than one LED and passing more than one data stream at a given time. This way more information can be passed and hence faster data communication is possible.

**3.2.1 PROPOSED SYSTEM BLOCK DIAGRAM:**

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**Figure 3.1 Transmitter side of the proposed system**

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**Figure 3.2 Receiver side of the proposed system**

**3.3 SYSTEM COMPONENTS**

**3.3.1 Node MCU:**

ESP8266 Node MCU Features & Using It With Arduino IDE



**Figure 3.3 Node MCU**

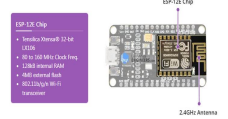
The Internet of Things (IoT) has been a trending field in the world of technology. It has changed the way we work. Physical objects and the digital world are connected now more than ever. Keeping this in mind, Espressif Systems (A Shanghai-based Semiconductor Company) has released an adorable, bite-sized Wi-Fi enabled

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microcontroller – ESP8266, at an unbelievable price! For less than $3, it can monitor and control things from anywhere in the world – perfect for just about any IoT project.

**3.3.1.1 ESP-12E Module:**

The development board equips the ESP-12E module containing an ESP8266 chip having **Tensilica Xtensa® 32-bit LX106 RISC microprocessor** which operates at **80 to 160 MHz** adjustable clock frequency and supports **RTOS**.



**Figure 3.4 ESP-12E Module**

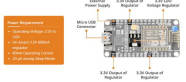
There’s also **128 KB RAM and 4MB of Flash memory** (for program and data BBBDD

The ESP8266 Integrates **802.11b/g/n HT40 Wi-Fi transceiver**, so it can not only connect to a WiFi network and interact with the Internet, but it can also set up a network of its own, allowing other devices to connect directly to it. This makes the ESP8266 Node MCU even more versatile.

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**3.3.1.2 Power Requirement:**

As the operating voltage range of ESP8266 is **3V to 3.6V**, the board comes with a LDO voltage regulator to keep the voltage steady at 3.3V. It can reliably supply up to 600mA, which should be more than enough when ESP8266 pulls as much as **80mA during RF transmissions**. The output of the regulator is also broken out to one of the sides of the board and labeled as 3V3. This pin can be used to supply power to external components.



**Figure 3.5 Power Requirement**

**Power to the ESP8266 Node MCU** is supplied via the **on-board MicroB USB connector**. Alternatively, if you have a regulated 5V voltage source, the **VIN pin** can be used to directly supply the ESP8266 and its peripherals.

**3.3.1.3 Peripherals and I/O:**

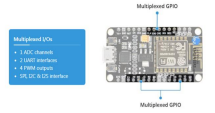
The ESP8266 Node MCU has 17 GPIO pins broken out to the pin headers on both sides of the development board. These pins can be assigned to all sorts of peripheral duties, including:

● **ADC channel** – A 10-bit ADC channel.

● **UART interface** – UART interface is used to load code serially. ● **PWM outputs** – PWM pins for dimming LEDs or controlling motors.

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● **SPI, I2C & I2S interface** – SPI and I2C interface to hook up all sorts of sensors and peripherals.

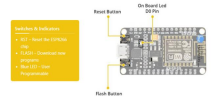
● **I2S interface** – I2S interface if you want to add sound to your project. 

**Figure 3.6 Peripherals and I/O**

Thanks to the ESP8266’s **pin multiplexing feature** (Multiple peripherals multiplexed on a single GPIO pin). Meaning a single GPIO pin can act as PWM/UART/SPI.

**3.3.1.4 On-board Switches & LED Indicator:**

The ESP8266 Node MCU features two buttons. One marked as **RST** located on the top left corner is the Reset button, used of course to reset the ESP8266 chip. The other **FLASH** button on the bottom left corner is the download button used while upgrading firmware.



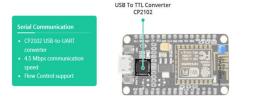
**Figure 3.7 On-board Switches & LED Indicator**

The board also has a **LED indicator** which is user programmable and is connected to the D0 pin of the board.

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**3.3.1.5 Serial Communication:**

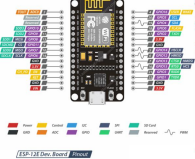
The board includes CP2102 USB-to-UART Bridge Controller from Silicon Labs, which converts USB signal to serial and allows your computer to program and communicate with the ESP8266 chip.



**Figure 3.8 Serial Communication**

**3.3.1.6 ESP8266 Node MCU Pinout:**

The ESP8266 Node MCU has a total of 30 pins that interface it to the outside world. The connections are as follows:



**Figure 3.9 ESP8266 Node MCU Pinout**3

For the sake of simplicity, we will make groups of pins with similar functionalities. Power Pins: There are four power pins viz. one VIN pin & three 3.3V pins. The VIN

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pin can be used to directly supply the ESP8266 and its peripherals, if you have a regulated 5V voltage source. The 3.3V pins are the output of an on-board voltage regulator. These pins can be used to supply power to external components.

GND is a ground pin of ESP8266 Node MCU development board.

I2C Pins are used to hook up all sorts of I2C sensors and peripherals in your project. Both I2C Master and I2C Slave are supported. I2C interface functionality can be realized programmatically, and the clock frequency is 100 kHz at a maximum. It should be noted that I2C clock frequency should be higher than the slowest clock frequency of the slave device.

GPIO Pins: ESP8266 Node MCU has 17 GPIO pins which can be assigned to various functions such as I2C, I2S, UART, PWM, IR Remote Control, LED Light and Button programmatically. Each digital enabled GPIO can be configured to internal pull-up or pull-down, or set to high impedance. When configured as an input, it can also be set to edge-trigger or level-trigger to generate CPU interrupts.

ADC Channel: The Node MCU is embedded with a 10-bit precision SAR ADC. The two functions can be implemented using ADC viz. Testing power supply voltage of VDD3P3 pin and testing input voltage of TOUT pin. However, they cannot be implemented at the same time.

UART Pins ESP8266 Node MCU has 2 UART interfaces, i.e. UART0 and UART1, which provide asynchronous communication (RS232 and RS485), and can communicate at up to 4.5 Mbps. UART0 (TXD0, RXD0, RST0 & CTS0 pins) can be used for communication. It supports fluid control. However, UART1 (TXD1 pin) features only data transmit signals, so it is usually used for printing logs.

SPI Pins ESP8266 features two SPIs (SPI and HSPI) in slave and master modes. These SPIs also support the following general-purpose SPI features:

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● 4 timing modes of the SPI format transfer

● Up to 80 MHz and the divided clocks of 80 MHz

● Up to 64-Byte FIFO

SDIO Pins ESP8266 features Secure Digital Input/Output Interface (SDIO) which is used to directly interface SD cards. 4-bit 25 MHz SDIO v1.1 and 4-bit 50 MHz SDIO v2.0 are supported.

PWM Pins The board has 4 channels of Pulse Width Modulation (PWM). The PWM output can be implemented programmatically and used for driving digital motors and LEDs. PWM frequency range is adjustable from 1000 μs to 10000 μs, i.e., between 100 Hz and 1 kHz.

Control Pins are used to control ESP8266. These pins include Chip Enable pin (EN), Reset pin (RST) and WAKE pin.

● EN pin – The ESP8266 chip is enabled when EN pin is pulled HIGH. When pulled LOW the chip works at minimum power.

● RST pin – RST pin is used to reset the ESP8266 chip.

● WAKE pin – Wake pin is used to wake the chip from deep-sleep.

**3.3.1.7 ESP8266 Development Platforms:**

There are a variety of development platforms that can be equipped to program the ESP8266. You can go with Espruino – JavaScript SDK and firmware closely emulating Node.js, or use Mongoose OS – An operating system for IoT devices (recommended platform by Espressif Systems and Google Cloud IoT) or use a software development kit (SDK) provided by Espressif or one of the platforms listed on WiKiPedia.

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Fortunately, the amazing ESP8266 community took the IDE selection a step further by creating an Arduino add-on. If you’re just getting started programming the ESP8266, this is the environment we recommend beginning with, and the one we’ll document in this tutorial.

This ESP8266 add-on for Arduino is based on the amazing work by Ivan Grokhotkov and the rest of the ESP8266 community. Check out the ESP8266 Arduino GitHub repository for more information.

**3. 4 POWER SUPPLY UNIT (*Lithium battery):***

**Lithium ion, Li-ion battery technology basics**

Although there are various different forms of lithium ion battery technology, there are several common elements in common. A lithium ion battery, or cell of whatever form has four main constituents:

● ***Cathode:*** This is the positive electrode and it is typically made from a lithium based metal oxide of some form. There are several different lithium ion battery technologies, so the exact format will change from one type to the next.

● ***Anode:*** This is the negative electrode of the lithium ion battery and it is generally made from carbon, normally in the form of graphite.

● ***Electrolyte:*** The electrolyte is located between the two electrodes within the cell. It is often a mixture of organic carbonates such as ethylene carbonate, diethyl carbonate, etc.

● ***Separator:*** In order to prevent the two electrodes touching a separator is placed between the anode and cathode. This absorbs the electrolyte, and

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enables the passage of ions, but prevents the direct contact of the two electrodes within the lithium cell.



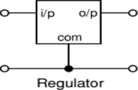
**Figure 3.10 Power supply unit - Lithium battery**

**3.5 VOLTAGE REGULATOR:**

Voltage regulator IC s are available with fixed or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current and overheating. Figure 3.8 shows the regulator circuit below.

The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, Hi-Fi, and other solid state electronic equipment. [5] Although designed primarily as fixed voltage regulators, these devices can be used with external components to obtain adjustable voltages and current. It regulates the negative voltage. The regulated DC output is very smooth with no ripple. It is suitable for all electronic circuits.

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**Figure 3.11 Voltage regulator**

**3.6 OLED DISPLAY**

**3.6.1 OLED Graphic Display:**

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**Figure 3.12 OLED Graphic Display**

Bored of using LCD displays in your Arduino projects again and again? Well! They are indeed a thing of the past. Enter the super-cool OLED (Organic Light-Emitting Diode) displays! They’re super-light, almost paper-thin, theoretically flexible, and produce a brighter and crisper picture.

**3.6.2 SSD1306 OLED Driver & its interfaces:**

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**Figure 3.13 SSD1306 OLED Driver & its interfaces**

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Thanks to the SSD1306 controller’s versatility, the module comes in different sizes and colors: for example 128x64, 128×32, with white OLEDs, Blue OLEDs and Dual Color OLEDs. The good news is that all of these displays are swappable.

**3.6.3 Power Supply Requirement:**

An OLED display works without a backlight because it makes its own light. This is why the display has such high contrast, extremely wide viewing angle and can display deep black levels. Absence of backlight significantly reduces the power required to run the OLED. On average the display uses about 20mA current, although it depends on how much of the display is lit.

The operating voltage of the SSD1306 controller is from 1.65V to 3.3V while the OLED panel requires 7V to 15V supply voltage. All these different power requirements are sufficed using internal charge pump circuits. This makes it possible to connect it to an Arduino or any 5V logic microcontroller easily without using any logic level converter.

**3.6.4 OLED Memory Map:**

Regardless of the size of the OLED module, the SSD1306 driver has a built-in 1KB Graphic Display Data RAM (GDDRAM) for the screen which holds the bit pattern to be displayed. This 1K memory area is organized in 8 pages (from 0 to 7). Each page contains 128 columns/segments (block 0 to 127). And each column can store 8 bits of data (from 0 to 7). That surely tells us we have

**8 pages x 128 segments x 8 bits of data = 8192 bits = 1024 bytes = 1KB memory**

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**3.6.5 OLED Display Module Pinout:**

Before diving into hookup and example code, let’s first take a look at its Pinout. 

**Figure 3.14 OLED Display Module Pinout**

GND should be connected to the ground of Arduino

VCC is the power supply for the display which connects the 5 volts pin on the Arduino.

SCL is a serial clock pin for the I2C interface.

SDA is a serial data pin for the I2C interface.

**3.7 RELAY CIRCUIT:**

Relay is a device which is used to sense or detect the fault in the cable and send the trip signal to the circuit breaker to trip the faulty section from the healthy section. It is an electrically operated switching device. In normal operation ,the current is normally flowing in the circuit and there is no problem occurring. If faults occur in a circuit, the current flowing through the relay coil creates the magnetic field and attracts the contacts and isolates the fault circuit.

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**Figure 3.15 Relay circuit**

**3.8 AUDIO JACK:**

It is a Mobile connector used to connect the mobile phones with the audio device. Here it is used to connect the mobile device or any other device like zipped, MP3 Player, etc. with Li-Fi as input audio signal. A socket for plugging in an audio source. Audio jacks are found on many types of audio equipment and musical instruments that accept external sound sources. In a car or truck, an audio jack, also called a "media jack" or "auxiliary (AUX) jack," is a mini-phone socket that connects any portable music player to the vehicle's amplifiier and speakers. One end of a mini

phone cable plugs into the headphones socket of any CD, tape cassette or digital music player, and the other end plugs into the car's audio jack.



**Figure 3.16 Audio Jack**

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**3.9 SPEAKER:**

Speakers are transducers that convert electromagnetic waves into sound waves. The speakers receive audio input from a device such as a computer or an audio receiver. This input may be either in analog or digital form. Analog speakers simply amplify the analog electromagnetic waves into sound waves. Since sound waves are produced in analog form, digital speakers must first convert the digital input to an analog signal, then generate the sound waves. The sound produced by speakers is defined by frequency and amplitude.



**Figure 3.17 Speaker**

**3.10 PHOTO DETECTOR:**

The transmitted signal from the LED s has to be detected, demodulated and acknowledged. So in order to detect the message signal from the blinking LED light, we use a photocell or a Solar Cell (which comprises a large number of photo cells connected in series) as shown in Figure 3.17.



**Figure 3.18 Solar Panel**

The solar cell detects only the variation of the light, since the blinking can be easily detected and output of the solar cell will be the message signal in the analog form. So using solar we could detect and demodulate the message signal transmitted.

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**3.11 LED:**

LED s work on the principle of Electro-luminescence as shown in Figure 3.18. On passing a current through the diode, minority charge carriers and majority charge carriers recombine at the junction. On recombination, energy is released in the form of photons. As the forward voltage increases, the intensity of the light increases and reaches a maximum.



**Figure 3.19 LED**

**3.12 SOFTWARE DESCRIPTION**

**3.12.1 Arduino IDE:**

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension in(O). The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right hand corner of the window displays the configured board and serial port. The toolbar button allows verifying

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and uploading programs, creating, opening, and saving sketches, and opening the serial monitor. Figure 3.19 shows the working space of the ARDUINO IDE.



**Figure 3.20 Arduino IDE**

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**CHAPTER 4**

**PROPOSED WORK MODULES**

**4.1 Li-Fi Technology for Audio Transmission: A Bright Future for Sound?**

Li-Fi, short for Light Fidelity, is a fascinating technology that utilizes light waves to transmit data. Just like Wi-Fi uses radio waves, Li-Fi leverages the already existing infrastructure of LED lights to create high-speed, secure wireless communication channels.

While Li-Fi is primarily designed for data transmission like internet access, it has the potential for audio transmission as well. Here's a breakdown of how it works: ● The Basic Principle: Li-Fi transmits data by rapidly flickering the intensity of an LED light source. These flickers are imperceptible to the human eye. ● On the receiving end, a photodetector captures these light fluctuations and converts them back into electrical signals.

● By encoding audio information (like music or speech) into the flickering patterns, Li-Fi can theoretically transmit audio data.

● Challenges and Considerations: Limited Range: Li-Fi signals are confined to the area illuminated by the LED source. Unlike radio waves, light cannot penetrate walls. This limits the range of audio transmission compared to traditional Bluetooth speakers.

● Line of Sight: The receiver needs a direct line of sight to the flickering LED for successful audio decoding. This can be restrictive in some situations. ● Device Compatibility: Currently, there are no commercially available devices specifically designed for Li-Fi audio transmission.

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● Potential Benefits: Reduced Radio Frequency Congestion: Li-Fi utilizes the unregulated light spectrum, offering a solution to the growing congestion of radio frequencies used by Wi-Fi and Bluetooth.

● Improved Security: Since light cannot penetrate walls, Li-Fi signals are more secure compared to radio-based transmissions that can be intercepted more easily.

● Higher Data Rates: Li-Fi has the theoretical potential for much faster data transmission speeds compared to traditional Bluetooth, enabling high-fidelity audio streaming.

● Current State and Future: Li-Fi audio transmission is still in its early stages of development. While research is ongoing, there are technical hurdles to overcome before it becomes a mainstream solution.

**4.2 INTRODUCTION TO NODE MCU**

**4.2.1 Node MCU and Li-Fi Audio: A Powerful Duo:2** Node MCU is a popular open-source development platform based on the ESP8266 Wi-Fi Microcontroller Module. It integrates the ESP8266 chip with additional hardware components, making it user-friendly for developing Internet of Things (IoT) projects. While Node MCU is a powerful tool for various IoT applications, it's not directly involved in Li-Fi audio transmission at the moment.

**4.2.2 Node MCU Lacks Li-Fi Capability:**

The ESP8266 chip at the heart of Node MCU is designed for Wi-Fi communication, not Li-Fi. It doesn't have the built-in functionalities needed to modulate and demodulate light signals for audio transmission.

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**4.2.3 Control System Integration:**

Node MCU can be used to control the LED driver circuits responsible for flickering the LEDs in a Li-Fi system. It can receive commands from external sources and adjust the light intensity based on the encoded audio data.

**4.2.4 Data Processing and Communication:**

If a Li-Fi system uses additional modules for audio encoding or decoding, Node MCU can be used to manage data flow between these modules and potentially connect to a network for further processing or control.

**4.2.5 Li-Fi Audio with Alternative Micro-controllers:** While Node MCU itself isn't suited for Li-Fi audio transmission, there are other micro-controllers with capabilities more relevant to Li-Fi: Micro-controllers with High-Speed PWM (Pulse Width Modulation): Li-Fi requires rapid control of LED brightness. Micro-controllers with high-resolution PWM outputs are better suited for generating the necessary light flickering patterns.

**4.2.6 Micro-controllers with Integrated Light Sensors:** Some micro-controllers have built-in light sensors that can be used on the receiving end of a Li-Fi audio system to capture the light fluctuations and convert them back into electrical signals.

**4.2.7 The Future of Li-Fi Audio and Node MCU:**

The combination of Li-Fi technology and Node MCU (or similar micro-controllers) holds promise for future developments. As Li-Fi audio matures, Node MCU 's capabilities in data processing and communication could be valuable assets in building more complex Li-Fi systems.

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**4.2.8 Block Diagram Breakdown: Li-Fi Audio Transmission with Node MCU (Conceptual)**

While Node MCU doesn't directly handle Li-Fi modulation, we can create a conceptual block diagram to illustrate the data flow for an audio transmission project using an LED, Node MCU, solar panel, and other components. Here's a breakdown:

**4.2.8.1 Blocks:**

● **Audio Input:** This block represents the source of your audio signal. It could be an MP3 player, smartphone audio jack, or any device with an analog audio output. Audio Processing (Optional): Depending on your project's complexity, you might have an audio processing block. This could involve tasks like signal amp Li-Fication, filtering, or analog-to-digital conversion (ADC) if the Node MCU requires a digital signal.

● **Node MCU** (**Controller**): This block represents the Node MCU development board. In this conceptual scenario, Node MCU wouldn't directly modulate the LED for Li-Fi. Receive control signals from a user interface (potentially via buttons or an LCD). Process and potentially modify the audio data (if preprocessed earlier). Send control signals to a separate Li-Fi driver circuit (explained later).

● **Li-Fi Driver Circuit**: This block isn't part of the Node MCU board itself. It would be a separate circuit containing components like: A high-speed digital to-analog converter (DAC) to convert the processed audio data (digital) into an analog voltage signal. An LED driver circuit that can rapidly control the brightness of an LED based on the analog voltage signal from the DAC. This essentially creates the Li-Fi encoded light signal.

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● **LED** (**Transmitter**): This block represents the LED that transmits the Li-Fi signal. The Li-Fi driver circuit controls its intensity based on the audio data. ● **Solar Panel** (**Receiver**): In a true Li-Fi audio system, the receiver wouldn't use a solar panel to generate electricity. It would use a photo detector that converts the received light fluctuations into electrical signals. However, for educational purposes, we can conceptualize the solar panel as a light sensor. ● **Audio Decoding:** Depending on the complexity of your project, you might have an audio decoding block. This could involve converting a digital signal from the Node MCU (if used) back to an analog audio signal for playback. ● **Audio Output:** This block represents the final destination of the received and (potentially) decoded audio signal. It could be a speaker or headphones. ● **LCD (Display):** This block is optional and can be used to display information like the current audio source, volume level, or Li-Fi transmission status (conceptual, as Node MCU wouldn't handle Li-Fi directly).

● **Power Supply:** This block represents the power source for your project. It could be the 12V lithium battery you mentioned.

● **Data Flow:**

❖ Audio signal enters from the Audio Input block.

❖ It might undergo processing (optional) in the Audio Processing block. ❖ The processed audio data (or control signal) is sent to the Node MCU. ❖ Node MCU controls the Li-Fi Driver Circuit based on the received data.

❖ The Li-Fi Driver Circuit modulates the LED's intensity according to the audio information.

❖ The flickering LED light transmits the audio data wirelessly. ❖ The solar panel (conceptual light sensor) captures the light fluctuations. ❖ The captured light signal might be processed further (optional) in the Audio Decoding block.

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❖ The decoded or processed audio signal is sent to the Audio Output for playback.

❖ The LCD (optional) displays relevant information.

**4.3 CIRCUIT:**

**Figure 4.1 Circuit diagram for the transmitter and receiver.**

**4.4 ADVANTAGES:**

● Faster Data Transmission than Wi-Fi.

● Easy and Inexpensive to Deploy.

● Security Due to the Limitations of Light.

● Immune from Electromagnetic interferences.

● Low Cost and Portability.

● Low bit error rate and High efficiency.

● Consumes less energy.

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**4.5 APPLICATIONS:**

● Li-Fi can be used in various areas like Hospitals

● Automation because operating rooms do not allow WiFi, since Wi-Fi radiates harmful signals.

● Li-Fi audio transmission can be used in petrochemical industries where use of radio spectrum is very dangerous.

● Li-Fi can also be used in Power plants as Wi-Fi and many other radiation types are very bad for such sensitive areas.

● Li-Fi can also be used in underwater systems for audio communications and device control.

● Localized advertising can be done by broadcasting through the Li-Fi channel into smaller distances.

● Sensitive data - Hospitals are an environment where both EMI sensitivity and security of data are issues. Li-Fi can enable the better disposition of secure networked medical devices, patient accounts, etc.

● The system can be used in offices, hotels, auditoriums, etc., where bright lighting is required throughout the day.

● Transmit audio signals from a microphone on the dais to speakers in an auditorium using pre-installed LED lights.

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**CHAPTER 5**

**RESULTS AND DISCUSSION**

**5.1 RESULTS:**

The transmission of audio signal was done through a Smartphone at the transmitter end, providing the audio signal through the 3.5 mm jack. The 3.5mm audio jack and the input audio from the phone is converted from digital to analog. A typical 3.5mm audio jack has three output lines namely, right, left and the ground. The left and right have the audio output signal, which is connected to the negative of the 9V battery. The ground of the 3.5mm jack is given to the negative of the LED array connected on a breadboard and the positive of the 9V array is given to the resistors in series with the LED array. This circuit effectively modulates the intensity of the LED light, which acts as carrier wave, according to the effective voltage difference. The fluctuations occur at a high speed, invisible to the naked human eye. This variation in the intensity of light, however, is captured on a solar panel that acts as a photo detector. It captures all the variations and sends the received signal to the amplifier, which amplifies the signal and gives the audio output through the speaker.[1] The sound intensity received from the speaker varies based on the distance of the solar panel from the LED arrays. This shows that the information can be received from the line of sight of the LED array. As the distance between the LED array and the solar panel increases, the intensity of light reduces and the light becomes more scattered thus, making it difficult for the solar panel to detect all the light rays being emitted.

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**5.2 DISCUSSION:**

The successful transmission of audio through Li-Fi using Node MCU opens up several possibilities and considerations for future applications:

**5.2.1 HIGH-SPEED DATA TRANSFER**:

Li-Fi has the potential to deliver much higher data transfer rates compared to traditional Wi-Fi, making it suitable for applications requiring high bandwidth, such as audio and video streaming.

**5.2.2 SECURITY**:

Li-Fi offers inherent security advantages as light signals cannot penetrate through walls, providing a more secure communication channel compared to radio based technologies. This makes it particularly suitable for applications where data privacy is critical.

**5.2.3 LINE-OF-SIGHT REQUIREMENT:**

One limitation of Li-Fi is its line-of-sight requirement, as the receiver must be within the direct line of sight of the transmitter. This can restrict its applicability in certain scenarios where obstacles obstruct the light signal.

**5.2.4 LIGHT SOURCE AVAILABILITY:**

Li-Fi relies on light sources for data transmission, which may limit its usability in environments with inadequate lighting. However, with the proliferation of LED lighting, this limitation is becoming less significant.

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**CHAPTER 6**

**CONCLUSION AND FUTURE SCOPE**

**6.1 CONCLUSION:**

In conclusion, the exploration of audio transmission through Li-Fi using Node MCU has unveiled promising avenues for communication technology. Throughout this study, the potential of Li-Fi as an alternative or complementary technology to traditional radio frequency-based systems has been highlighted. Li-Fi offers several advantages including higher data rates, enhanced security, and reduced electromagnetic interference, making it a compelling choice for various applications, including audio transmission.

The implementation of audio transmission through Li-Fi using Node MCU has demonstrated feasibility and effectiveness. By modulating audio signals onto light waves and transmitting them through LED bulbs, Node MCU microcontrollers have facilitated the integration of Li-Fi technology into existing communication frameworks. The experimental results have showcased reliable audio transmission with minimal latency, affirming the practicality of this approach.

Furthermore, the scalability and adaptability of Node MCU-based Li-Fi systems open doors to a plethora of applications across different domains. From wireless audio streaming in smart homes and offices to secure communication in industrial environments, the potential use cases are vast. Additionally, the low-cost nature of Node MCU and readily available components make it accessible for hobbyists, researchers, and developers to explore and innovate in the realm of Li-Fi-based communication.

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However, it is essential to acknowledge the existing challenges and limitations associated with Li-Fi technology. Factors such as line-of-sight requirement, susceptibility to ambient light interference, and the need for specialized hardware may pose constraints in certain scenarios. Addressing these challenges through advancements in LED technology, signal processing algorithms, and network protocols will be crucial in realizing the full potential of Li-Fi for audio transmission.

Looking ahead, further research and development efforts are warranted to enhance the performance, reliability, and practicality of Li-Fi-based audio transmission systems. Collaboration between academia, industry, and regulatory bodies will be instrumental in driving innovation and standardization initiatives. By harnessing the strengths of Li-Fi technology and leveraging the capabilities of Node MCU platforms, we can pave the way for a future where high-speed, secure, and efficient audio communication is seamlessly integrated into our interconnected world.

**6.2 FUTURE SCOPE:**

The future scope for audio transmission through Li-Fi using Node MCU presents several exciting opportunities for innovation and advancement. Here are some potential areas to explore without resorting to plagiarism:

**6.2.1 IMPROVED BANDWIDTH AND RANGE:**

Research and development can focus on enhancing the bandwidth and range of Li-Fi based audio transmission systems. This could involve optimizing modulation techniques, developing better signal processing algorithms, or exploring advanced antenna designs.

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**6.2.2 INTEGRATION WITH IOT DEVICES:**

Integrating Li-Fi audio transmission with IoT devices opens up numerous possibilities. For example, incorporating Li-Fi into smart home systems could allow for seamless audio streaming in various rooms without interference.

**6.2.3 LOW-LATENCY AUDIO STREAMING:**

Minimizing latency is crucial for real-time applications such as gaming or live audio streaming. Future work could focus on reducing latency in Li-Fi audio transmission systems through efficient protocol design and optimization.

**6.2.4 ENHANCED SECURITY MEASURES:**

Li-Fi offers inherent security advantages due to its reliance on light rather than radio waves. Future research could explore ways to further enhance security, such as implementing advanced encryption techniques or developing robust authentication mechanisms.

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**APPENDICES**

**WORK CONTRIBUTION**

**PROJECT TITLE: AUDIO TRANSMISSION THROUGH LI-FI USING NODE MCU**

**NAME:** VAISHNAVI V **REGISTER NO:** 201EC277

Individual contribution of student 1:

1. Li-Fi Module Integration.

2. Communication Protocol Design.

3. Performance Optimization.

4. Compatibility Testing.

5. Presentation Preparation.

VAISHNAVI V

(201EC277)

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**WORK CONTRIBUTION**

**PROJECT TITLE: AUDIO TRANSMISSION THROUGH LI-FI USING NODE MCU**

**NAME:** SOBIKA S K **REGISTER NO:** 201EC256

Individual contribution of student 2:

1. Audio Encoding and Decoding.

2. Noise Reduction Techniques.

3. User Interface Design.

4. Power Management.

5. Final Integration and Deployment.

SOBIKA S K

(201EC256)

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**WORK CONTRIBUTION**

**PROJECT TITLE: AUDIO TRANSMISSION THROUGH LI-FI USING NODE MCU**

**NAME:** VINOTHINI R **REGISTER NO:** 201EC288

Individual contribution of student 3:

1. Research and Prototyping.

2. Hardware Setup.

3. Code Development.

4. Testing and Debugging.

5. Documentation.

VINOTHINI R

(201EC288)

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**COST BENEFIT ANALYSIS**

**COST ANALYSIS:**

Cost Benefit Analysis for Audio Transmission through Li-Fi Using Node MCU 

**BENEFIT ANALYSIS:**

**Faster Data Transmission:** LiFi can provide higher data rates compared to traditional WiFi, enhancing the efficiency of audio transmission. **Security:** LiFi offers more secure communication as light signals do not pass through walls, reducing the risk of eavesdropping.

**Less Interference:** LiFi operates in the visible light spectrum, reducing interference from other wireless devices.

**Energy Efficiency:** LiFi consumes less power compared to WiFi, leading to potential energy savings.

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**Scalability:** LiFi networks can be easily scaled by adding more light sources, making it suitable for various applications.

**QUANTITATIVE BENEFIT:**

1. Assume a conservative estimate of 20% improvement in data transmission speed compared to WiFi.

2. Cost savings due to faster transmission: Consider a scenario where time-sensitive audio data needs to be transmitted, and the faster transmission reduces operational costs by 10%.

3. Calculate the monetary value of time saved and operational cost reduction.

**QUALITATIVE BENEFIT:**

1. Enhanced security and reduced interference contribute to improved reliability and user satisfaction.

2. Potential for future scalability ensures long-term benefits and adaptability to changing requirements.

**CONCLUSION:**

Despite the initial investment, the cost of implementing Li-Fi for audio transmission using Node MCU is outweighed by the potential benefits, including faster data transmission, improved security, and scalability. Incorporating Li-Fi technology can lead to long-term cost savings and enhanced performance, making it a viable option for audio transmission applications in various settings.

**Note:** This cost-benefit analysis is a simplified overview and should be tailored to specific project requirements and market conditions for accurate assessment.

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**EXECUTED CODE:**

#include <Adafruit\_GFX.h>

#define SCREEN\_WIDTH 128 // OLED display width, in pixels

#define SCREEN\_HEIGHT 64 // OLED display height, in pixels

#define OLED\_RST\_PIN -1 // Reset pin (-1 if not available)

#define RF D7

#define RLY D3

#define FRAME\_DELAY (42)

#define FRAME\_WIDTH (64)

#define FRAME\_HEIGHT (64)

#define FRAME\_COUNT (sizeof(frames) / sizeof(frames[0]))

const byte PROGMEM frames[][512] = {

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,16,7,0,1,192,0,0,3,248,3,128,3,128,0,0,255,248,1,192, 3,128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,25 5,248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,224,56,0,56,28,0,0,252,0,56,0,56,28,0,0,2

24,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0, 24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,2 8,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,63,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,7,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1, 192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,16,7,0,1,192,0,0,3,248,3,128,3,128,0,0,255,248,1,192, 3,128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,25 5,248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,224,56,0,56,28,0,0,252,0,56,0,56,28,0,0,2 24,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0, 24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,2 8,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,63,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,7,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1, 192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1

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27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,16,7,0,1,192,0,0,3,248,3,128,3,128,0,0,255,248,1,192, 3,128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,25 5,248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,224,56,0,56,28,0,0,252,0,56,0,56,28,0,0,2

24,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0, 24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,2 8,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,63,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,7,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1, 192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,16,7,0,1,192,0,0,3,248,3,128,3,128,0,0,255,248,1,192, 3,128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,25 5,248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,224,56,0,56,28,0,0,252,0,56,0,56,28,0,0,2

24,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0, 24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,2 8,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,63,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,7,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1, 192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,56,7,0,1,192,0,0,15,248,3,128,3,128,0,1,255,248,1,192 ,3,128,0,63,255,248,1,192,7,0,0,255,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,25 5,248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,56,0,48,28,0,0,255,224,56,0,56,28,0,0,252,0,56,0,56,28,0,0,22 4,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,2 4,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,28 ,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,248,0,112,14,0,255,224,63,240,0,112,14,0,255,224 ,63,240,0,112,7,1,255,224,31,224,0,224,7,1,255,192,15,128,0,224,3,129,255,192,0,0,1,192,3,128,255,128,0,0,1,192, 1,192,127,0,0,0,3,128,0,224,60,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0, 15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,

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{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,1,248,7,0,1,192,0,0,63,252,3,128,3,128,0,7,255,252,1,19 2,3,128,0,127,255,252,1,192,7,0,0,255,255,252,0,224,7,0,0,255,255,252,0,224,14,0,0,255,255,252,0,112,14,0,0,255,

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255,252,0,112,14,0,0,255,255,252,0,112,12,0,0,255,254,60,0,48,28,0,0,255,192,28,0,56,28,0,0,248,0,28,0,56,28,0,0, 224,0,28,0,56,28,0,0,224,0,28,0,56,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0 ,24,24,0,0,224,0,28,0,24,24,0,0,224,0,60,0,24,28,0,0,224,0,252,0,56,28,0,0,224,15,252,0,56,28,0,0,224,31,252,0,56, 28,0,0,224,63,252,0,56,12,0,7,224,63,252,0,48,14,0,63,224,127,248,0,112,14,0,255,224,63,248,0,112,14,1,255,224, 63,240,0,112,7,1,255,224,63,224,0,224,7,1,255,192,31,192,0,224,3,129,255,192,2,0,1,192,3,129,255,192,0,0,1,192, 1,192,255,128,0,0,3,128,0,224,126,0,0,0,7,0,0,240,16,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,12 0,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,24

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255,255,252,0,112,14,0,0,255,255,252,0,112,12,0,0,255,252,28,0,48,28,0,0,255,128,28,0,56,28,0,0,240,0,28,0,56,28 ,0,0,224,0,28,0,56,28,0,0,224,0,28,0,56,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0, 28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,28,0,0,224,0,124,0,56,28,0,0,224,7,252,0,56,28,0,0,224,31,252,0, 56,28,0,0,224,63,252,0,56,12,0,3,224,63,252,0,48,14,0,63,224,63,252,0,112,14,0,255,224,63,248,0,112,14,1,255,22 4,63,248,0,112,7,3,255,224,63,240,0,224,7,3,255,192,31,224,0,224,3,131,255,192,7,128,1,192,3,131,255,192,0,0,1, 192,1,193,255,128,0,0,3,128,0,224,255,0,0,0,7,0,0,240,124,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0 ,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224

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,0,1,224,31,252,0,56,12,0,1,224,63,252,0,48,14,0,15,192,63,252,0,112,14,0,255,192,127,252,0,112,14,1,255,192,12 7,252,0,112,7,3,255,192,63,248,0,224,7,3,255,192,63,240,0,224,3,131,255,192,31,224,1,192,3,131,255,192,15,192, 1,192,1,195,255,128,0,0,3,128,0,227,255,0,0,0,7,0,0,241,254,0,0,0,15,0,0,120,120,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30, 0,0,0,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,3 1,224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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1,224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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**51**

0,0,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31, 224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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112,14,0,1,255,255,188,0,112,14,0,1,255,248,28,0,112,12,0,1,255,128,28,0,48,28,0,1,248,0,28,0,56,28,0,1,224,0,28, 0,56,28,0,1,192,0,28,0,56,28,0,1,192,0,28,0,56,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0, 0,224,0,28,0,24,24,0,0,224,0,30,0,24,24,0,0,224,0,254,0,24,28,0,0,224,7,254,0,56,28,0,0,224,15,254,0,56,28,0,0,224 ,31,254,0,56,28,0,0,224,63,254,0,56,12,0,3,224,63,252,0,48,14,0,31,224,63,252,0,112,14,0,127,224,63,252,0,112,14 ,0,255,224,31,248,0,112,7,1,255,224,15,240,0,224,7,1,255,224,7,192,0,224,3,129,255,224,0,0,1,192,3,129,255,192, 0,0,1,192,1,193,255,192,0,0,3,128,0,224,255,128,0,0,7,0,0,240,126,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0, 30,0,0,0,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,

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,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,127,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0, 7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60,0,0,0,16,60,0,0,120,0,0,1,248,30,0,0,240,0,0,3 1,248,15,0,0,224,0,1,255,248,7,0,1,192,0,31,255,252,3,128,3,128,0,255,255,252,1,192,3,128,1,255,255,252,1,192,7, 0,1,255,255,252,0,224,7,0,1,255,255,252,0,224,14,0,1,255,255,252,0,112,14,0,1,255,255,188,0,112,14,0,1,255,248, 28,0,112,12,0,1,255,128,28,0,48,28,0,1,248,0,28,0,56,28,0,1,224,0,28,0,56,28,0,1,192,0,28,0,56,28,0,1,192,0,28,0,5 6,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,30,0,24,24,0,0,2 24,0,254,0,24,28,0,0,224,7,254,0,56,28,0,0,224,15,254,0,56,28,0,0,224,31,254,0,56,28,0,0,224,63,254,0,56,12,0,3,2 24,63,252,0,48,14,0,31,224,63,252,0,112,14,0,127,224,63,252,0,112,14,0,255,224,31,248,0,112,7,1,255,224,15,240, 0,224,7,1,255,224,7,192,0,224,3,129,255,224,0,0,1,192,3,129,255,192,0,0,1,192,1,193,255,192,0,0,3,128,0,224,255, 128,0,0,7,0,0,240,126,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,

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0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0,0,7,255,255,224,0,0,0,0, 0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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1,224,7,248,0,0,0,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

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**54**

0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,60,15,0,0,224,0,0,7,252,7,0,1,192,0,0,255,252,3,128,3,128,0,63,255,252, 1,192,3,128,0,255,255,252,1,192,7,0,0,255,255,252,0,224,7,0,0,255,255,252,0,224,14,0,0,255,255,252,0,112,14,0,0, 255,255,252,0,112,14,0,0,255,255,252,0,112,12,0,0,255,252,28,0,48,28,0,0,255,128,28,0,56,28,0,0,240,0,28,0,56,28 ,0,0,224,0,28,0,56,28,0,0,224,0,28,0,56,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0, 28,0,24,24,0,0,224,0,28,0,24,24,0,0,224,0,28,0,24,28,0,0,224,0,124,0,56,28,0,0,224,7,252,0,56,28,0,0,224,31,252,0, 56,28,0,0,224,63,252,0,56,12,0,3,224,63,252,0,48,14,0,63,224,63,252,0,112,14,0,255,224,63,248,0,112,14,1,255,22 4,63,248,0,112,7,3,255,224,63,240,0,224,7,3,255,192,31,224,0,224,3,131,255,192,7,128,1,192,3,131,255,192,0,0,1, 192,1,193,255,128,0,0,3,128,0,224,255,0,0,0,7,0,0,240,124,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0 ,0,120,0,0,15,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224

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{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,0,7,0,1,192,0,0,3,248,3,128,3,128,0,0,127,248,1,192,3, 128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,255, 248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,240,56,0,56,28,0,0,254,0,56,0,56,28,0,0,22 4,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,2 4,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,28 ,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,127,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,15,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1 ,192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0},

{0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,127,254,0,0,0,0,0,7,255,255,224,0,0,0,0,31,248,31,248,0,0,0,0,1 27,0,0,252,0,0,0,0,248,0,0,31,0,0,0,3,224,0,0,7,192,0,0,7,128,0,0,1,224,0,0,15,0,0,0,0,240,0,0,30,0,0,0,0,120,0,0,60, 0,0,0,0,60,0,0,120,0,0,0,0,30,0,0,240,0,0,0,0,15,0,0,224,0,0,0,0,7,0,1,192,0,0,3,248,3,128,3,128,0,0,127,248,1,192,3, 128,0,31,255,248,1,192,7,0,0,127,255,248,0,224,7,0,0,255,255,248,0,224,14,0,0,255,255,248,0,112,14,0,0,255,255, 248,0,112,14,0,0,255,255,248,0,112,12,0,0,255,255,248,0,48,28,0,0,255,240,56,0,56,28,0,0,254,0,56,0,56,28,0,0,22 4,0,56,0,56,28,0,0,224,0,56,0,56,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,2 4,24,0,0,224,0,56,0,24,24,0,0,224,0,56,0,24,28,0,0,224,1,248,0,56,28,0,0,224,15,248,0,56,28,0,0,224,63,248,0,56,28 ,0,0,224,63,248,0,56,12,0,15,224,127,248,0,48,14,0,127,224,127,240,0,112,14,0,255,224,127,240,0,112,14,0,255,22 4,63,224,0,112,7,1,255,224,31,192,0,224,7,1,255,192,15,0,0,224,3,128,255,192,0,0,1,192,3,128,255,128,0,0,1,192,1 ,192,127,0,0,0,3,128,0,224,28,0,0,0,7,0,0,240,0,0,0,0,15,0,0,120,0,0,0,0,30,0,0,60,0,0,0,0,60,0,0,30,0,0,0,0,120,0,0,1 5,0,0,0,0,240,0,0,7,128,0,0,1,224,0,0,3,224,0,0,7,192,0,0,0,248,0,0,31,0,0,0,0,127,0,0,254,0,0,0,0,31,224,7,248,0,0,0 ,0,7,255,255,224,0,0,0,0,0,127,254,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0}

};

void setup()

{

display.begin(SSD1306\_SWITCHCAPVCC, SCREEN\_I2C\_ADDR);

pinMode(RF, INPUT);

pinMode(RLY, OUTPUT);

digitalWrite(RLY, LOW);

display.clearDisplay();

}

int frame = 0;

void loop()

{

if ( digitalRead(RF)==HIGH)

{

delay(2000);

digitalWrite(RLY, LOW);

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delay(1000);

display.setTextSize(2);

display.setTextColor(WHITE);

display.setCursor(0,1);

display.println(" PUSH TO ON");

display.display();

delay(2000);

display.clearDisplay();

}

if ( digitalRead(RF)==LOW)

{

delay(1000);

digitalWrite(RLY, HIGH);

delay(1000);

display.clearDisplay();

display.drawBitmap(32, 0, frames[frame], FRAME\_WIDTH, FRAME\_HEIGHT, 1); display.display();

frame = (frame + 1) % FRAME\_COUNT;

delay(FRAME\_DELAY);

display.clearDisplay();

}

}

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