Transmission of Audio signals using Visible Light Communication via LEDs

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Abstract: ***With the episodic increase of advancement in technology, wireless communication has become the need of the hour. The rate at which the use of wireless technology is being developed is tremendous. However, with the increase in usage, there has been unfortunately an increase in network complexity. In order to resolve the crisis of radio frequency spectrum, a newly developed technology has been proposed. This technology has been coined as Li-Fi: Light Fidelity. It is a technology, based on Visible Light Communication, which is used to transmit signals and data from one system to another with the help of a Led. The paper proposes a transmission system which will be responsible for transmitting audio signals from one system to another with the help of Li-Fi. Here a light emitting diode acts as the Li-Fi transmitter and photodiode acting as a Li-Fi receiver.The spontaneous switching of the Led enables propagation of signals through a wireless channel and is picked up by the receiving photodiode. The photodiode adhering to its functiontransforms the optical signals into electrical signals and therefore original data is retrieved and transferred. Additionally, with proposition to the system, a comparative study has been delineated with the already existing system.The existing system of networking and communications involve Wi-fi. The emergence and usage of Li-fi is necessary because it offers a substantially similar user experience to Wi-Fi except using the light spectrum. It is essential as it will able to meet up the connectivity demands of future as it is able to unlock unprecedented data and bandwidth.***

Keywords: Li-Fi, Light Emitting Diode (LED), Photodiode, Visible Light Communication (VLC) Wireless Communication.

I. INTRODUCTION

With the advancement in wireless technology, the rate at which the wireless communication is made possible between two devices is exponentially increasing. However, with the increase in access to the wireless network to the devices, the network has become both overloaded and complex. This has led to the failure in providing adequately high data rate. Henceforth there is an indispensable need of introducing new means of wireless network, which are fast and reliable. The problem could be solved with the use of Li-Fi technology. This technology was suggested by Dr. Harald Haas, proposing a solution called D-Light In order to resolve the problems of unavailability of Wi-Fi [3].The method of Li- Fi technology is based on the phenomenon of Visible Light Communication (VLC). Visible light is the only prevalent wave in Electromagnetic Spectrum which is capable of being perceived by human visionary [2]. Visible Light communication provides a larger bandwidth and higher data rate than the present radio frequency because of the large unallocated spectrum available. The spectrum varies from 380 nm to 750 nm corresponding to a frequency spectrum of 430 Hz to 790 Hz which is high when evaluated against radio frequency based systems [1]. The use of Visible Light Communication is now becoming available due to development of Light emitting diodes. LED is more beneficial than the existing incandescent because of long life expectancy, high tolerance to humidity, low power consumption, and minimal heat generation lighting [9].

Compared with the already prevailing lighting methods, white LED has advantages such as lower power consumption and lower voltage, longer lifetime, smaller size, and cooler operation.

The paper proposes a wireless transmission system in which audio signals are transmitted with the usage of Light-Fidelity. It includes the usage of LED as a Li-Fi transmitter. The LEDs can be switched ON and OFF at a very rapid rate which is not noticeable by human eye, thus the light source appears to be constant and switching off remains of the led remains invisible. When these signals are transmitted to the receiver through the wireless channel, the photo diode, which acts as the receiver, converts these optical signals to electrical signals and the original information is obtained.

This paper is organized as follows. In section III, the already present concept of wireless communication using bluetooth and Wi-Fi are discussed. In section IV, the feature of the proposed system as communication devices is shown. In section V, the hardware circuit of the proposed work is shown. Finally, the conclusions are given in section VIII.

II.EXISTING SYSTEM OF DATA TRANSMISSION

Figure 1 illustrates the working flow of the currently prevalent system of wireless communication, which depends upon the usage of electromagnetic waves. The two such consistent sources are that of Wi-Fi and Bluetooth. In ustilizin any of these cases, these strategies utilizes a radio frequency range and the noise in such cases is extremely high [5]. Different hindrances to these strategies are an uncommon hardware necessity, high power utilization, and staggering expense, accessibility of secure information transmission. transmission it is destructive to well being.

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Fig 1. Block diagram of data transfer through Wi-fi/ Bluetooth

III. PROPOSED METHODOLOGY OF THE AUDIO SIGNAL TRANSMITTING SYSTEM

Figure 2 gives the bock diagram of the proposed methodology, consisting of two divisions. The idea consists of taking an audio signal as the input. The audio signal of primary concern is a musical audio data of mp3 format. This input signal can be obtained or streamed from any mobile phone or any mp3 player or any other audio source. With the help of transmitter circuit arrangement the signal is transmitted to the white LED. The signals from the LED are then detected with the help of the photo detector, which are then amplified and processed and finally the respective audio signal is heard in the speaker as the output. Thus there is a transmission of the audio signal from the source of the audio signal to the speaker with the help of light. The transmitter section and the receiver section is elaborated separately further.

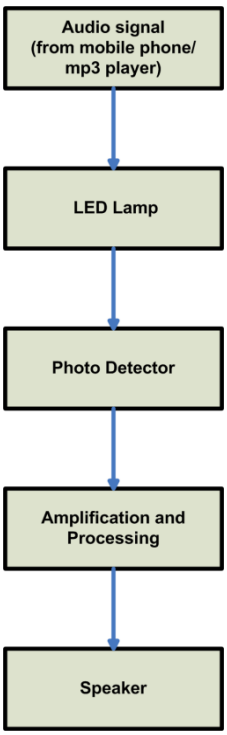

Fig.2 Block diagram of the proposed design

A. Transmitter Section

Figure 3 illustrates the circuit diagram of the transmitter circuit, comprising of three BC337 common emitter amplifiers, three 4.7 kilo ohm resistors, and three 1 kilo ohms resistors, three 2.2 micro farad capacitor and a 1 watt white led. The power supply to the circuit is provided using a 12 V DC battery. The input to the transmitter side is an audio signal. For an audio source options available are the usage of an mp3 player, mobile phone or a microphone with pre-amplifier. The audio signal is converted into a pulse wave format by using BD135. This transistor compares the input signal with a reference voltage and produces output in Pulse wave form. This obtained pulsed form is at a low voltage level which is not sufficient to drive the led. In order to resolve this, the transmitter circuit is built using transistorized amplifier. The transmitter circuit consists of three common emitter (CE) amplifiers connected in parallel to amplify the audio signal along with a few passive elements which are paired with one watt light emitting diode [4]. The capacitors are present at the base of each transistor for blocking DC signals which could degrade the quality of output. The amplified signal is used to drive the led. The light emitting diode changes its brightness with respect to audio signal. However the change in the intensity of brightness of light emitting diode because of the audio signal is not visible to the perception of human eye. The only thing which can be perceived is the static illumination of white led [6]. The led transmit the audio signal to the receiver.

B. Receiver Section

Figure 4 gives the circuit diagram for the receiver section, comprising of a photo detector, an amplifier and a speaker for the output. The transmitted signal from the LED needs to be detected, demodulated and acknowledged. In order to detect the message from the blinking LED, a photo detector is used [6]. The photo detector used in this methodology is a solar cell. The solar cells used are of a 6 volt although solar cells above 3 volts are also suitable and sufficient. These solar cells are used in series with 2.2uf capacitor which is paired with the amplifier [4]. The solar cells detect the variation of light through blinking of the led and give the output of signal in analog form. This signal is the demodulated signal at a low voltage. It is then amplified using to an arbitrary value using an amplifier. The amplifier arrangement is similar to the transmitter amplifier arrangement in order to clear any occurring phase errors. Additionally good sensitivity is an important characteristic for the amplifier. The received signal from the amplifier passes to the speaker which converts the electrical signal into audio form using electromagnets present in the speaker [10].

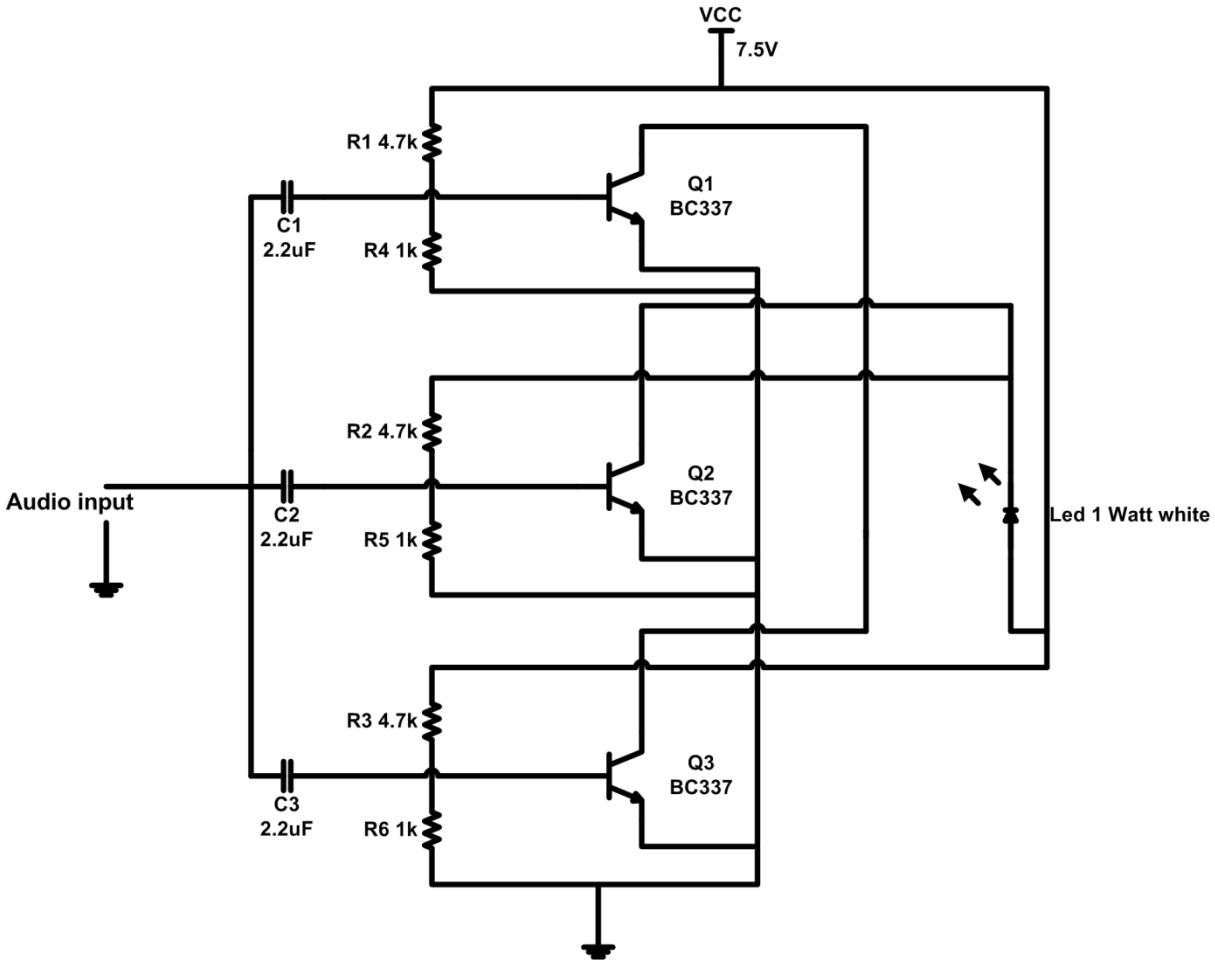

Fig.3 Circuit diagram for the input section

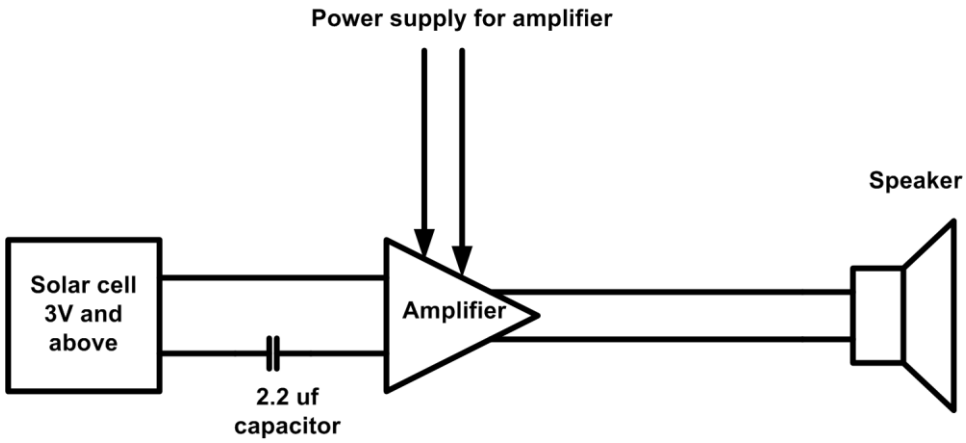

Fig.4 Circuit diagram for the output section

In order to get an almost noise free sound from the speaker, the band equalizer in the audio source and the distance between the solar panel and light source require adjustment. The maximum distance between the transmitter and receiver depends on the number of amplifier stages. In this case a three stage amplifier network has been implemented. For a three stage Common Emitter amplifier, the maximum distance is about two metres with LED illuminance of 13,842.00 lux at the receiver side. For a five-stage Common Emitter amplifier, the distance can be up to 2.6 metres with LED illuminance of 17,382.00 lux. The observations demonstrate that as the number of Common Emitter amplifier stages connected in parallel increases, the intensity of LED light also increases. This in turn leads to an increment in the maximum distance from which the sound can be heard from the speaker.

IV. WORKING OF THE PROPOSED SYSTEM

Figure 3 gives the circuit diagram of the transmitter circuit. Based on the fact that carrier waves can take signals along destinations, photons with speed of light can be used to carry signals of low frequency from a source to a required destination. Therefore the transmitter circuit is built

with the aim of modulating light with low frequency signals. Figure 4 gives the circuit configuration of the receive circuit is illustrated in figure 4. The components used in the designing of the transmitter and receiver circuit are listed in table 1.

Table I. Component Specifications

S. No	Component name	Item specification
1.	Transistor BC337	NPN, 50V, 800mA
2.	Capacitor	2.2 uF
3.	Resistors	4.7 k and 1k
4.	Solar Panel	3V
5.	Audio Jack	3.5mm
6.	Audio Jack Receiver End	3.5mm
7.	DC Battery	Non Rechargeable 12V
8.	Potentiometer	100 ohm

The input to the transmitter circuit is an audio signal taken from an audio source. For the working of the circuit the input is very low frequency audio signal of 20 Hz to 20 kHz. The audio signal then passes through the 2.2 uF capacitors where there is removal and filtering of any present Direct Current components. The audio signal is converted into pulse wave form with BD135. The signal is then amplified by the BC337 common emitter amplifier. This amplified signal drives the LED. The LED emits light according to amplified signal. As the blinking of the LED is controlled by the input signal, it takes nanoseconds therefore is undectable by the human eye. The regulated circuit needs to be maintained at a constant output level, for which the power supply uses LM 7805. This provides a regulated 9 V to the circuit.For the receiver section of the circuit, 3 V solar cells rated at 200 mA are used for detecting the light from the transmitting LEDs. This leads to generation of an analog output corresponding to the input signal. The frequency of the analog signal is same as that of the input signal. This similarity is because the flickering of the LED is controlled by the input signal and the solar cell is responsible for detecting only the fluctuations in the LED and produces an output. The output is then amplified using the similar transistorized amplifier using BC337 common emitter amplifier. This also eliminates any phase changes occurring in the transmitted signal. The amplified signal is fed to the speaker. The speaker converts the analog signal into an audible sound signal with the help of the electromagnet present in the speaker.

V. EXPERIMENTAL RESULTS AND DISCUSSION

In this research, a wireless communication device to transmit audio signal through light has been designed and implemented. The proposed circuit configuration consists of two sections; the transmitter section and the receiver section. Figure 5 illustrates the hardware circuit design for the transmitter circuit. The transmitter section modulate incoming audio signal and transmit to the receiver section in the form of visible light using LED. Figure 6 illustrates the hardware circuitry of the receiver section. The receiver section receives and interprets the incoming light, detecting it via solar cell and converts it into audible sound signal with the usage of speaker.

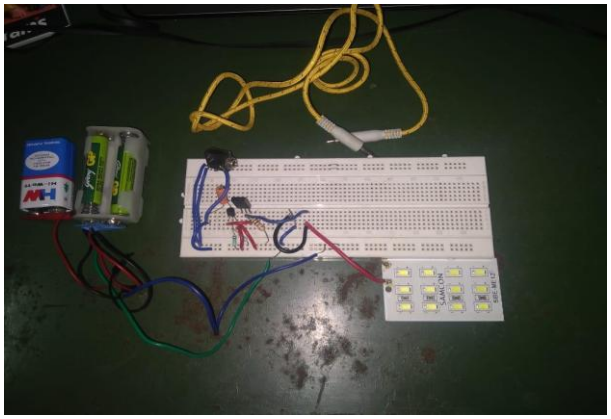

Fig.5 Hardware circuit of the transmitter section

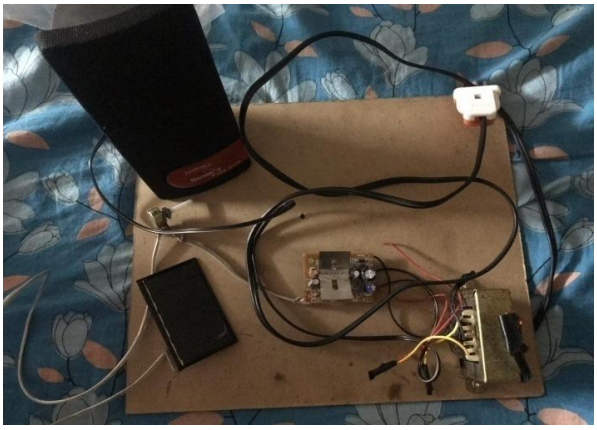

Fig.6 Hardware circuit of the receiver section

The testing of the circuit was done in a room where there was unavailability of ambient light. Also there was no provision for availability of a nearby electrical source. In order to test the circuit, the 1 watt led was placed parallel to the solar cell. After that the power supply for both transmitter and the receiver was turned on. The power supply was provided with through 9 V non rechargeable batteries to both the transmitter and the receiver circuit. This was followed by the providing of a low frequency audio input, of about 20 Hz to 20 kHz, to the transmitter and adjusting the volume to the transmitter with the help of the 100 ohm potentiometer. The audio signal was amplified via BC337 common emitter amplifier configuration in order to drive the 1 watt LED. The blinking of the LED was detected by 300 V, 20mA solar cell. The solar cell output was then passed to the amplifier arrangement similar to transmitter amplifier setup. The amplified output is transferred to the speaker. This resulted in a clear audio sound at the receiving end through the speaker. Therefore the transmission of the sound through light was successfully carried out. The input frequency versus output frequency is recorded in the form and is tabulated as in table 2.

Table 2. Recorded Input and Output frequency

S. No	Input frequency(Hz)	Output frequency(hz)
1.	25	25.2
2.	300	299.8
3.	450	450.002
4.	600	600.03
5.	700	700.02
6.	800	799.99
7.	1100	1100.12

The graphical representation of the tabulation is shown in figure 7.

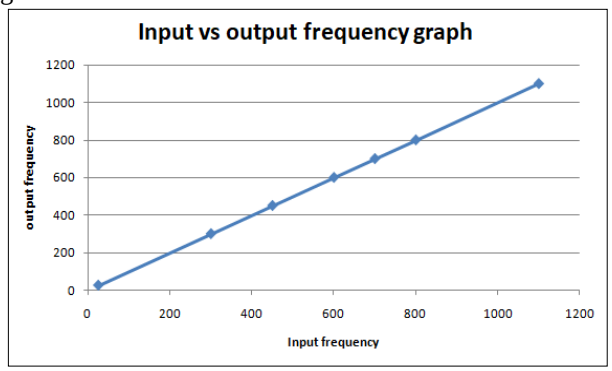

Fig.7 Input versus output frequency

The graph of input frequency versus output frequency is linear in nature showing that the audio signal at the output end was successfully transmitted from one end to another.

During the testing it was observed that as the number of Common Emitter amplifier stages connected in parallel increased, the intensity of LED light also increased. This inturn led to an increment in the maximum distance from which the sound can be heard from the speaker.

VI. CONCLUSION

In this paper audio signals have been transmitted from one place to another with the help of light. This process bolsters the use of light as a means of communication. The innovation of light for communication is still under research and most likely it will be a leap forward in correspondence. By providing a test concerned with sending of an audio signal by light, Li-Fi has the potential to attract a large number of researchers, aiming at a great scope of improvement of technology [11]. Security, cost effective, facilitated data transmission are some of the advantages which will prove to benefit light fidelity as a new technology. The proposed methodology is a small scale effort which can be extended to several applications such as development of Li-Fi hotspots for home applications [8], airplane applications [1] and many more.

With these numerous ascendencies visible light communication proves to be a promising technology in the field of communication.Li-Fi is a developing innovation and subsequently it has immense potential. A great deal of research shows possibility in this filed. As of now, great deals of researchers are engaged with a broad research in this field. With the continuous effective utilization of this technology, it is possible that soon hotspots similar to that of Wi-Fi hotspots are made available. As the measure of accessible data transmission is restricted, the wireless transmissions are ending up progressively obstructed, making it increasingly harder to get a working and reliable signal which operates at high speed. The Li-Fi innovation can resolve this emergency. One of the noble applications involves the multicasting of the audio signals using light communication and then using it to send location information to aid the visually impaired people [12].

Moreover with the help of Li-Fi internet access may be provided in prohibited areas. Such places include theatres and aircrafts where the conventional internet access is not allowed because of the use of the radio frequency spectrum [1].

Also adding to the advancement in the proposed principle the screens of mobiles, television and tube lights can be accounted as transmission device [7]. The photo detector can be replaces with cameras in mobile phones for scanning and retrieving the data.

Li-FI can likewise be executed in schools, universities, exhibition halls, inns, medical clinics and so forth. In spots like clinics where electromagnetic beams are destructive Li-Fi can be utilized. It can likewise be utilized in an unsafe situation like the warm power plant and atomic power plant without causing electromagnetic impedance [8]. Subsequently Wi-Fi can be supplanted by Li-Fi.

REFERENCES

1. Aman Singla, Divyata Sharma and Sharda Vashisth, “Data Connectivity in Flights using Visible light communication,” IEEE International Conference on Computing and Communication Technologies for Smart Nation (IC3TSN), 2017
2. Toshihiko Komine and Masao Nakagawa, “Fundamental Analysis for Visible-Light Communication System using LED Lights,” IEEE Transactions on Consumer Electronics, Vol. 50, No. 1, pp. 100-107 February 2004.
3. Jay H. Bhut, Dharmrajsinh N. Parmar, and Khushbu V. Mehta, “LI-FI Technology – A Visible Light Communication,” International Journal of Engineering Development and Research, pp.25-28, January 2014.
4. Syifaul Fuada and Trio Adiono, “Short range Audio Transfer through 3 Watt White Led on LoS channels,” IEEE International Symposium on Intelligent Signal Processing and Communication Systems, November 6-9, 2017, Xiamen, China.
5. M. Sharmila1, M. Shrin Shifana, V. Theebica, V. Sangeethapriya and Mrs. M. Prathibha, “Audio Transmission Using Li-Fi Technology,” International Research Journal of Engineering and Technology (IRJET), Vol.05, pp. 413-417, April 2018.
6. Nabil Abd Rabou, Hiroaki Ikeda, Hirofumi Yoshida, and Shigenobu Shinohara, “Optical Fiber Transmission of Multi-Channel FM audio and video signals,” IEEE Transactions on Consumer Electronics, Vol. 39, No. 3, pp. 593-597, August 1993.
7. Sridhar Rajagopal, Richard D. Roberts and Sang-Kyu Lim, “IEEE 802.15.7 Visible Light Communication: Modulation Schemes and Dimming Support,” IEEE Communications Magazine Volume:50 , Issue: 3 , pp. 72-82, March 2012
8. Rachel Kobo, Khmaies Ouahada, Richard Ndjiongue, and Olorato Precious Lekgotle, “Home Intercommunication System Using Visible Light Communications,” IIMC International Information Management Corporation, 2017.
9. M.Mutthamma, “A survey on Transmissionof data through illumination-Li-Fi,” International Journal of Research in Computer and Communication Technology, Vol 2, Issue 12, pp. 1427-1430,December 2013.

10. Grantham K. H. Pang, Chi-Ho Chan, and Thomas T. O. Kwan, "Tricolor Light-Emitting Diode Dot Matrix Display System with Audio Output," IEEE Transactions on Industry Applications, Vol. 37, No. 2, pp. 534-540, March-April 2001.
11. Abdelmoujoud Assabir , Jamal Elmhamdi , Ahmed Hammouch and Abdellatif Akherraz, "Application of Li-Fi Technology in the Transmission of the Sound at the Base of the PWM," IEEE 2nd International Conference on Electrical and Information Technologies ICEIT'2016.
12. E. B. Adoptante, Jr, K. D. Cadag, and V. R. Lualhati, "Audio Multicast by Visible Light Communication for Location Information for the Visually Impaired," 8th IEEE International Conference Humanoid, Nanotechnology, Information Technology Communication and Control, Environment and Management (HNICEM), December 2015.

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