SSRG International Journal of Electronics and Communication Engineering Volume 6 Issue 5, 9-15, May 2019
ISSN: 2348 – 8549 /doi:10.14445/23488549/IJECE-V6I5P103

Audio Signal Processing And Visualization With Li-Fi

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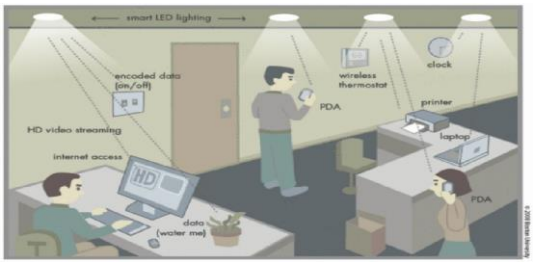
Abstract

This project develops an automatic vehicular communication system using Li-Fi technology, which provides improved efficiency by enabling vehicles to communicate by sending and receiving commands or help related messages with each other. Inter-vehicle communication is an effective method in which the communication takes place within the vehicles by which transmit various messages such as ignition on/off, sunroof on/off, wiper on/off, directions of the car, oil leakage, door open, need for some help. In Li-Fi technology, for communication in the vehicle, data is transmitted using an LED bulb or Laser, and at receiving end, we use a photodetector like a solar panel to receive the data. The usage of a Laser beam instead of complex wireless and as well as wired networks. Li-Fi (Light Fidelity) is an emerging technology that uses the visible light spectrum for communication. This project focuses on the automatic operation of a car, safety on roads in which consists of Li-Fi acting as a transmitter communicate with a photosensor or solar panel acting as a receiver. The application is cost-effective as Laser are cheap and simple algorithms are proposed for audio signal generation, processing, transmission, and visualization. The basic transceiver and receiver circuits are implemented, and the results are connected through Arduino to the system by using LabVIEW to visualize the audio signal or operation part of the car. The car moves in corresponding to the commands, and this helps to make the driving easy.

Keywords — *Light Fidelity(Li-Fi), Arduino, LabVIEW, signal transmission.*

I. INTRODUCTION

Li-Fi transmission of data through illumination by taking the fiber out of fiber optics by sending data through a Laser that varies in intensity faster than the human eye can follow. Li-Fi is the term some have used to label the fast and cheap wireless-communication system, which is the optical version of Wi-Fi. The term was first used in this context by Harald Haas in his TED Global talk on Visible Light Communication. "At the heart of this technology is a new generation of high brightness light-emitting diodes," says Harald Haas from the University of Edinburgh, UK," Very simply, if the LED is on, you transmit a digital 1, if it is off, you transmit a 0," Haas says, "They can be switched on and off very quickly, which gives nice opportunities for transmitted data."It is possible to encode data in the light by varying the Laser rate on and off to give different strings of 1s and 0s. The Laser intensity is modulated so rapidly that the human eye cannot notice, so the output appears constant.



II. LITERATURE REVIEW

Using a standard Laser, researchers at the Heinrich Hertz Institute in Berlin, Germany, have reached data rates of over 500 megabytes per second. Li-Fi Consortium was formed in October 2011 by a group of companies and industry groups to promote high-speed optical wireless systems and overcome the limited radio-based wireless spectrum. According to the Li-Fi Consortium, it is possible to achieve more than the 10 Gbps of speed, theoretically, which would allow a high-speed film to be downloaded in just 30 seconds. Laser light helps the fastest data transmission. Researchers at the University of Strathclyde in Scotland have started the task of reducing the time limit.

III. SYSTEM IMPLEMENTATION

The power supply is connected to the Li-Fi module and Arduino. The audio signal from the external source, like the mobile phone, to the LiFi module. In the LiFi module, the LiFi transmitter section converts the audio signal to an electrical signal with the mono audio amplifier TDA2003A; based on the sound waves, the variation occurs in the intensity of the laser beam, which is connected to the transmitter section. Then the output laser beam of the transmitter section in the LiFi module is reflected in the solar panel, which is placed in the receiver section at a maximum distance of 35 feet. The solar panel in the receiver section converts the visible light from the Laser LED to the electrical signal with the mono audio amplifier TDA2003A. Then the electrical signal is connected to

the speaker helps to hear the audio signal from the audio player or mobile phone. The electrical signal from the receiver section of the LiFi module is connected to the Arduino module, and the serial output of Arduino connected to the PC with the help of LabVIEW software helps to visualize the audio signal in graphical representation

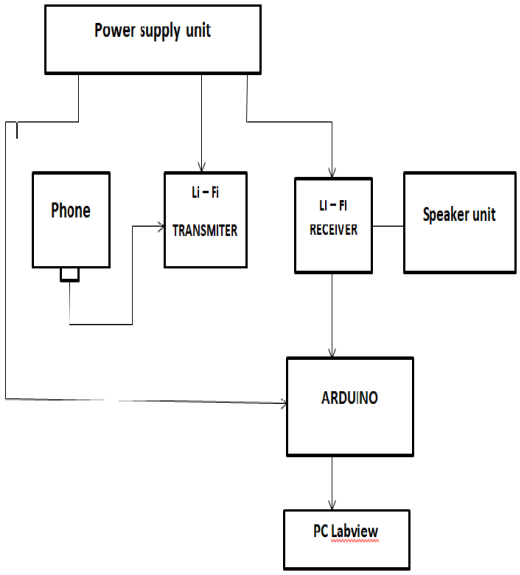


Figure-2: Block diagram Li-Fi Module

A. Circuits

The power supply is connected to the filter capacitors, which are connected to the amplifier VCC part. The other side of the amplifier is grounded. The output from the amplifier is resistor dividing occurs and feedback through inverting terminal of the op-amp through inverting filters. The audio signal from the external source, like a mobile phone connected to a variable resistor that controls the audio signal, which passes through the non-inverting stabilizing capacitor to the non-inverting terminal of the op-amp. Then the output is connected to the RC circuit. Similar to the transmitter section, the receiver section works, but the output of the transmitter is a laser beam. Based on the sound waves, variation occurs in the laser beam's intensity, which is connected to the transmitter section. Then the output laser beam of the transmitter section in the LiFi module is reflected in the solar panel, which is placed in the receiver section at a maximum distance of 35 feet. The solar panel in the receiver section converts the visible light from the Laser LED to an electrical signal. Then the electrical signal is connected to the speaker helps to hear the audio signal from the mobile phone. The electrical signal from the receiver section of the LiFi module is connected to the Arduino module. The serial output of Arduino connected to the PC or system with LabVIEW software helps to visualize the audio signal in graphical representation.

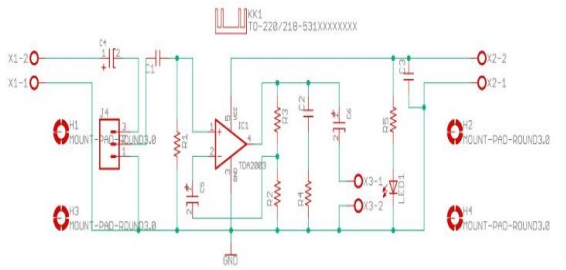


Figure 3: circuit diagram of a transmitter

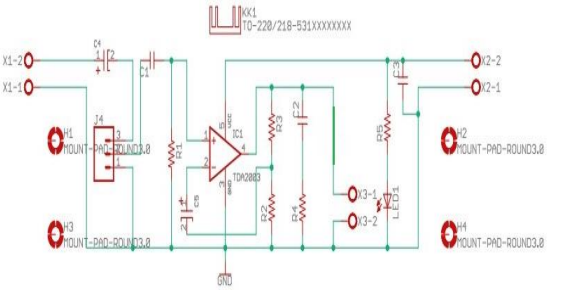


Figure 4: circuit diagram of a receiver

Methods of Visible Light Communication

- Devices used for Visible Light Communication
- Communication using a solar panel.

B. Transmitter of visible light communication

1) Visible Laser Light:

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. The term "laser" word means "Light Amplification by Stimulated Emission of Radiation." A laser differs from other sources of light in that it emits light coherently. Spatial coherence allows a laser beam to stay narrow over a great distance, enabling applications such as laser pointers. The Laser can also have high temporal coherence, which allows them to emit light with a very narrow spectrum, i.e., they can emit a single color of light. Here we use a 5w laser diode for audio signal transmission.

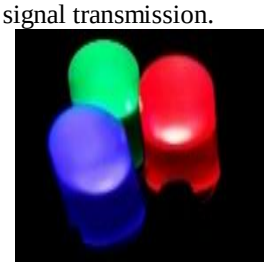


Figure-5: Laser Light

C. The receiver device of visible light communication

1) Solar panel:

Photovoltaic solar panels absorb sunlight as a source of energy to generate electricity. A photovoltaic (PV) module is a packaged, connected assembly of typically 6000 photovoltaic solar cells.

Figure-6: solar panel

2) *Merits of communication using solar panel*:

- The number of signals: Multiple.
- Robustness: no cross-talk or no Interference.
- Distance: Very Long (2km).
- Space Resolution: Each pixel

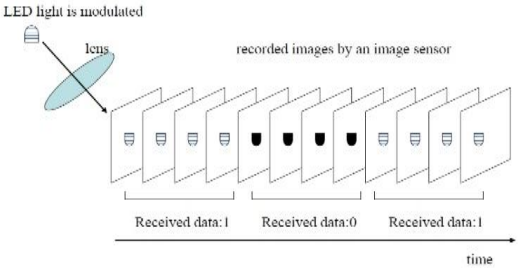


Figure-7: Principles of Communication Using a solar panel

3) *Power Supply*:

- Transformer block
- Rectifier block
- Filtering block
- Regulator block

It is an electrical device that supplies electrical power to an electrical load. The electrical parameters like voltage, current, frequency-converted to the power load. Input power is an electrical current. DC power supplies AC power.

Transformer to convert the input voltage to higher or lower AC voltage. The rectifier is to convert the transformer output voltage to varying DC voltage. Electronic filter which DC voltage is passed through the filter to convert it to an unregulated DC voltage. Regulator block converts DC voltage to constant. It reduces the magnetic ripple and noise.

4) *Li-Fi module*:

Li-Fi stands for Light Fidelity. Li-Fi technology provides data transmission through a laser beam that varies in intensity faster than the human eye can follow. This product focus on developing a Li-Fi based system and analyze its performance concerning existing technology.

The Li-Fi receiver is designed with a solar panel that receives the light with data. The distance covered a maximum of 35 feet without any obstacle. Connect Transmitter of LiFi to Receiver of TTL, Receiver of LiFi to Transmitter of LiFi power supply 12v (5v regulator). A laser source is soldered to the Transmitter board. AUDURINO used to Transmitter and Receiver boards for handling serial data communication.

Figure-8: Li-Fi module

5) *Working of Li-Fi module*:

- On one end, all the data will be connected to a Laser driver; when the led is turned on, the microchip converts the digital data in the form of light.
- A light-sensitive device like a solar panel (photodetector) receives the signal and converts it back into original data. This method of using rapid light to transmit information wirelessly is technically referred to as Visible Light data Communication

6) *Speaker:*

A speaker that has a 4ohm volt is an electroacoustic transducer that converts an electrical audio signal into a corresponding sound signal. The speaker operates on the same basic principle as a dynamic microphone but in reverse to produce a sound signal from an electrical signal. The sound source must be amplified or strengthened with an audio power amplifier before the signal transmission.

Figure-9: Speaker

7) *Mono Audio amplifier (TDA2003A):*

The TDA22003A is used as a mono audio amplifier. TDA22003A provides a high output current (up to 3.5A) with very low harmonic and crossover distortion. The TDA2003 is a low-cost audio chip amplifier that can put out some really clear sounds. It is typically used for car audio amplifiers, but it also works great as a bedroom amplifier or anywhere else that needs good audio without tons of power.

Completely safe operation is guaranteed due to DC and AC circuit potential between all pins and ground, a thermal limiting circuit, load dump voltage surge protection up to 40 V, and protection diodes in cases of accidental open ground.

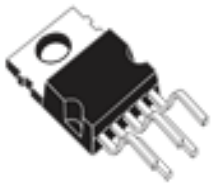


Figure-10: TDA2003A

The Power supply input 14 VDC, Output 6 W, 4Ω input resistance 150 KΩ, Very low harmonic and crossover distortion, IC built-in short circuit, thermal over-range, load dump voltage surge protected. Onboard preset to adjust volume, Terminal pins for connecting audio input. Screw terminal connector for easy power supply input and speaker connection Four mounting holes of 3.2 mm each with nut and stud PCB dimensions 33 mm x 71 mm

8) Arduino:

Arduino is an open-source hardware and software company, project, and user community that designs and manufactures single-board microcontrollers and microcontroller kits for building digital devices and interactive objects that can sense and control objects in the physical and digital world. Its products are licensed under the GNU Lesser General License (LGPL) or GNU General Public License (GPL), permitting the manufacture of Arduino boards and software distribution by anyone. Arduino boards are available commercially in preassembled form or as Do it yourself (DIY) kits.

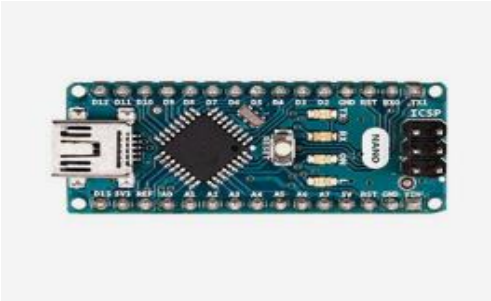


Figure-11:Arduino

Arduino is used for sending the audio signal to LabVIEW. Li-Fi is typically implemented using a white Laser at the downlink transmitter. These devices are normally used for illumination only by applying a constant current. However, by fast and subtle variations of the current, the optical output can vary at extremely high speeds. This very property of the optical current is used in the Li-Fi setup. The operational procedure is very simple-,data from the internet, and local network is used to modulate the intensity of the laser light source, if any, undetectable to the human eye.

Laser or LED are found in traffic and street lights, car brake lights, remote control units, and countless other applications) can be switched on and off faster than the human eye can detect, causing the light source to appear to be on continuously, even though it is, in fact, 'flickering.' information can therefore be encoded in the light by varying the rate at which the LEDs flicker on and off to give different strings of 1s and 0s. This method of using rapid pulses of light to transmit information without wire is technically referred to as Visible Light Communication (VLC), though it is potential to compete with conventional Wi-Fi, the speed of data transmission increased in Li-Fi.

9) Visible Light Communication (VLC)-"A potential solution to the global wireless spectrum shortage":

Li-Fi (Light Fidelity) is a fast and cheap optical version of Wi-Fi, based on Visible Light Communication (VLC). Visible Light Communication is a data communication medium, which uses visible light between 400 THz (780 nm) and 800 THz (375 nm) as an optical carrier for data transmission and illumination. It uses high-intensity light to transmit data information wirelessly.

The main components of this communication system are

- a high brightness Laser, Which acts as a communication source and
- a solar panel which shows good response to wavelength region serving as the receiving element.

LED can be switched on and off to generate digital strings of 1s and 0s.

10) Comparison between current and future wireless technology:

LI-FI is a term used to describe visible light communication technology applied to high-speed wireless communication. It acquired this name due to the similar to WI-FI, only using light instead of radio waves. Wi-Fi is great for general wireless coverage within buildings, and Li-Fi is ideal for high-density wireless data coverage in a confined area and for relieving radio interference issues, so the two technologies can be considered complimentary. Radio waves in the Wi-Fi cause health problems.

TABLE I
Comparison between current and future wireless technology

Technology	Speed	Data Density
Wireless (current)		
Wi-Fi – IEEE 802.11n	150 Mbps	*
Bluetooth	3 Mbps	**
IrDA	4 Mbps	***
Wireless (future)		
WiGig	2 Gbps	**
Giga-IR	1 Gbps	***
Li-Fi >1Gbps	1 Gbps	****

The table also contains the current wireless technologies that can be used for transferring data between devices today, i.e., Wi-Fi, Bluetooth, and IrDA. Only Wi-Fi currently offers very high data rates.

TABLE III
Comparison b/w Li-Fi and Wi-Fi

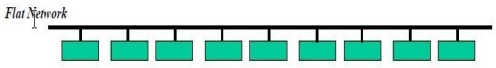
Parameter	Wi-Fi	Li-Fi
Speed	About 150 MBps	>1GBps
Carrier	Radio Waves	Visible Light
Operating Frequency	2.4-5 GBps	Hundreds of THz
Cost	More than Li-Fi	Less than Wi-Fi
Security	Can penetrate walls so need secure techniques to protect data.	Cannot penetrate walls so data is more secure than Wi-Fi.

11) *CAN PROTOCOL:*

A Controller Area Network (CAN) is a robust vehicle bus standard designed to allow microcontrollers and devices to communicate with each other in applications without a host computer. It is a message-based protocol designed originally for multiplex electrical wiring within automobiles.

The modern automobile's biggest processor is the engine control unit. Others are used for transmission, airbags, antilock braking, electric power steering, audio systems, power windows, doors, mirror adjustment, battery and recharging systems for cars. Some of these form independent subsystems, but communications, among others, are essential.

12) *CAN-based network:*



The CAN advantage is that interconnection between different vehicle systems can allow a wide range of safety and features to be implemented using software alone functionality, adding cost and complexity using traditional automotive electrics. Examples include: Auto start/stop: Various sensor inputs from around the vehicle (speed sensors, steering angle, air conditioning on/off, engine temperature) are complained via the CAN bus to determine whether the engine can be shut down when stationary for improved fuel economy and emissions. Some high performance in Audi and BMW models incorporate this feature. Sensors can be placed at the most suitable place, and its data used by several ECU. For example, outdoor temperature sensors (traditionally placed in the front) can be placed in the outside mirrors, avoiding heating by the engine, and data used by both the engine and the driver display.

13) *ECU:*

ECU In the Automobile industry, an electronic control unit (ECU) is an embedded electronic device; a digital computer that reads signals coming from sensors placed at various parts and in different components of the car and depending on this information controls various important units, e.g., engine and other automated operations within the car among many. Types of ECU ECM - Engine Control Module EBCM - Electronic Brake Control Module PCM- Vehicle Control Module BCM - Body Control Module.

14) *AUTOSAR PROTOCOL:*

AUTOSAR or AUtomotive Open System Architecture was developed to create a common standardized software architecture for designing automotive electronic control units (ECUs). The AUTOSAR architecture is based on a 3-layered architecture model, developed jointly by the automotive industry stakeholders, including – the automobile manufacturers, the suppliers, and the tool developers. The AUTOSAR specifies a three-layer architecture categorized into the following modules: Basic software (BSW). Runtime environment (RTE. Application layer. MCAL (Microcontroller Abstraction Layer), Basic Software Layer (BSW), Run-Time Environment (RTE), Application Layer

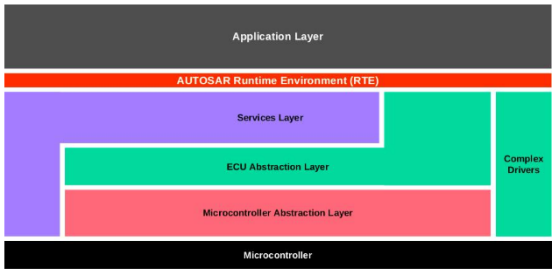


Figure-12: The 3-Layer AUTOSAR Software Architecture

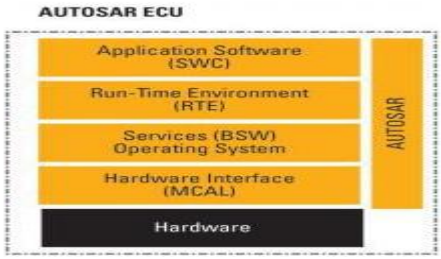


Figure-13: AUTOSAR ECU

In this AUTOSAR layered architecture, Communication Stack or ComStack facilitates communication. Hence ComStack can be defined as a software stack that provides communication services

to the Basic Software Modules and Application Layer or Application Software. We will first focus on generic ComStack and then introduce to the specification of CAN Communication Stack in AUTOSAR.

15) *LIN PROTOCOL:*

The LIN consortium designed LIN. The consortium members are mainly European car constructors such as Audi AG, BMW AG, Daimler Chrysler AG, Volkswagen AG, Volvo Cars Corporation AB, Motorola, and Volcano Communications Technologies. Many car constructors are currently implementing LIN in their vehicles like PSA. It was particularly designed for low-cost communication between smart sensors and actuators in automotive applications. It is intended to be used when high bitrates communications as CAN bus are not needed. It can be based on the UART/SCI hardware interface, software UART or state-machine

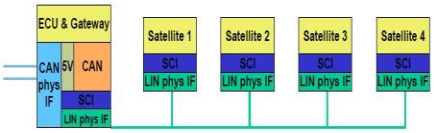


Figure-14: LIN

A LIN network consists of a LIN master and one or several LIN slaves. Usually, in an automotive application, the LIN bus is connected between a smart sensor or actuators and an Electronic Control Unit (ECU), which is often a gateway with CAN bus. Advantages are easy to use, Components available, Cheaper than CAN and other communications busses, Harness reduction, More reliable vehicles, Extension easy to implement. The LIN master knows the sequential order of all data to be transmitted and sends requests to slaves. These requests are achieved by sending a header.

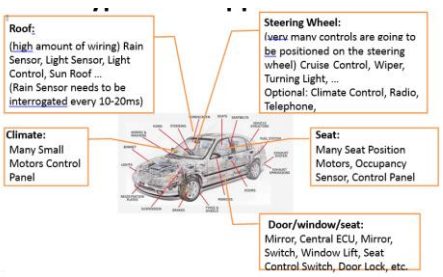
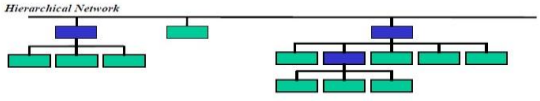


Figure-14: LIN protocol in Automobile car

16) *CAN + LIN:*



17) *LabVIEW:*

LabVIEW is a graphical programming language that uses icons instead of lines of text to create applications. In contrast to text-based programming languages, where instructions determine program execution, LabVIEW uses dataflow programming, where the flow of data determines execution. In LabVIEW, we build a user interface with a set of tools and objects. The user interface is known as the front panel. Then add code using graphical representations of functions to control the front panel objects. The block diagram contains this code. In some ways, the block diagram resembles a flowchart. LabVIEW programs are called virtual instruments, or VIs, because their appearance and operation imitate physical instruments, such as oscilloscopes and multimeters. Every VI uses functions that manipulate input from the user interface or other sources and display that information or move it to other files or other computers

18) *Result:*

The audio sound was transmitted from the transmitter section; the Laser started blinking. The laser light digitally transmitted the audio signal to the receiver. Now, when the receiver module is brought in a line of sight of the transmitter, the solar panel receives the audio signal and sends it to the speaker. The range of audio transmission was tested to be about 35 feet. This is so because, after this distance, the light gets scattered and could not fall properly on the solar panel. The layout of the LiFi module is shown in the figure.

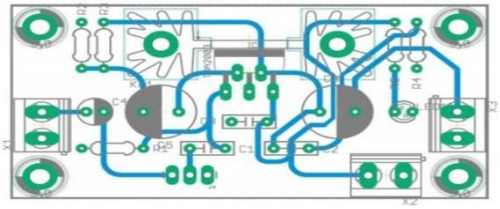


Figure-16: Layout of LiFi module

Automatic operations of inter-vehicular communication is an effective method in which the communication takes place within the vehicles by which transmit various messages such as ignition on/off, sunroof on/off, wiper on/off, directions of the car, oil leakage, door open, need for some help, ambulance alert. In Li-Fi technology, for communication, in-vehicle data is transmitted using a Laser, and at receiving end, we use a photodetector to receive the data. The usage of Laser eliminates the light beams need for complex wireless and as well as wired networks. Li-Fi (Light Fidelity) is an emerging technology that uses the visible light spectrum for communication. This project focuses on the safety on roads in which consists of Laser or LEDs acting as transmitter communicate with photo sensors acting as a receiver. The application is cost-effective as Laser are cheap and simple algorithms are proposed for signal generation and transmission. The basic transceiver and receiver circuits are implemented, and the results are connected through Arduino to the

various parts of the car. The car moves in corresponding to the commands, and this helps to make the driving easy. These systems work efficiently and engineer very well by using different sources available.

If LI-FI technology can be put into practical use, every LED is used to transmit data and lead toward a brighter future. The output of the Li-Fi module is connected to Arduino and connected to the PC with the help of LabVIEW software help as to audio signal processing in visual form. Arduino is used for sending the audio signal to LabVIEW. In LabVIEW, we will receive the audio signal through visa communication, and we will process it by taking some samples, if necessary, to send the processed audio signal through IOT(Gmail). The figure shows the output of the audio signal received in the receiver demonstrated in LabVIEW

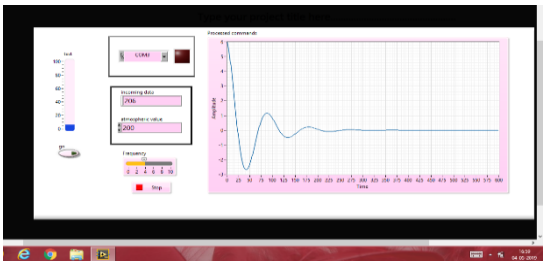


Figure-17: Visualization of the audio signal

IV. CONCLUSION

Li-Fi has great technology in the field of wireless data transmission. It is Conventional advanced methods of wireless communications that use light as a data carrier. Many Enhancements can be made to the existing technology; by using fast-switching LEDs, data transmission rates can be further enhanced. The driving speed of the circuit can be improved by using fast-switching transistors. Li-Fi is a feature key of high-speed data transmission. This project can be used in Robotics control; Heavy machinery controls in various industries.

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