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Li-Fi Audio Transmission

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Abstract: *Li-Fi Stands For Light-Fidelity. Li-Fi Is Transmission Of Data Using Visible Light By Transmitting Data Through An Led Light Bulb That Operates So Rapidly Than The Human Eye Can Follow. If The Led Is On, The Photo Detector Transmits A Binary One; Otherwise It's A Binary Zero. The Idea Of Li-Fi Was Introduced By A German Physicist, Harald Hass. The Term Li-Fi Was First Introduced By Haas In His Ted Global Talk On Visible Light Communication (Vlc). According To Hass, The Light, Which He Referred To As "Dlight", Can Be Used To Produce Higher Data Rates Up To 1 Giga Bits Per Second Which Is Much More Faster Than Our Broadband Services Used Today. This Prototype Discusses The Implementation Of The Basic Li-Fi Based System To Transmit Sound Signal From One Device To Another.The Purpose Is To Demonstrate Visible Light Communication (Vlc) Through An Led And Receive The Signal At The Receiver Through A Detector. The Sound Transferred By Led In The Form Of Visible Light Is Detected At The Receiver Without Fading.*

Keywords: *Antennas, Vlc, Leds.*

I. Introduction

Over The Past Few Decades There Has Been A Tremendous Growth In The Usage Of Rf Region Of The Electromagnetic Spectrum. This Is Due To Therapid Growth In The Number Of Cellular Phones Installations In Recent Times. This Affects A Rapid Loss In Free Spectrum For Future Devices. Light-Fidelity (*Li-Fi*) Operates In The Visible Light Spectrum From The Electromagnetic Spectrum I.E. It Makes Use Of Visible Light As A Transfer Of Medium Rather Than The Radio Waves.

The High Speed Is Achieved From*li-Fi* Can Be Explained Using Frequency Spectrum Of Electromagnetic Radiations. As Shown In The Electromagnetic Spectrum, The Frequency Band Of The Visible Light Is In Between 430thz To 770thz And On The Other Side Radio Frequency Band Is In Between 1hz To 3thz. Hence, The Frequency Bandwidth Of The Visible Light Is About 400 Times Longer Than The Radio Frequency Bandwidth. So More Bits Can Be Transferred Through This Bandwidth Than In The Radio Frequency Bandwidth. Hence Data Rate Transmission Rate Will Be High. Using *Li-Fi* We Can Transmit 'N' Number Of Signals That Can Be Transferred Using Conventional *Wi-Fi* Network. That Can Be Image, Sound Signal, Internet Connectivity Etc...But The Merits Of Li-Fi Over The *Wi-Fi* Network Are Data Transmission Rate Is High, Increase In Security, More Number Of Connected Devices, And Less Cost. In Coming Years, Li-Fi Will Change The Current Scenario And Achieve Tremendous Success. It Is Estimated That The Approximate Compound Annual Growth Of *Li-Fi* Market Will Be Of 82% From 2015 To 2018 And To Be Worth Over $6 Billion Per Year By 2018.

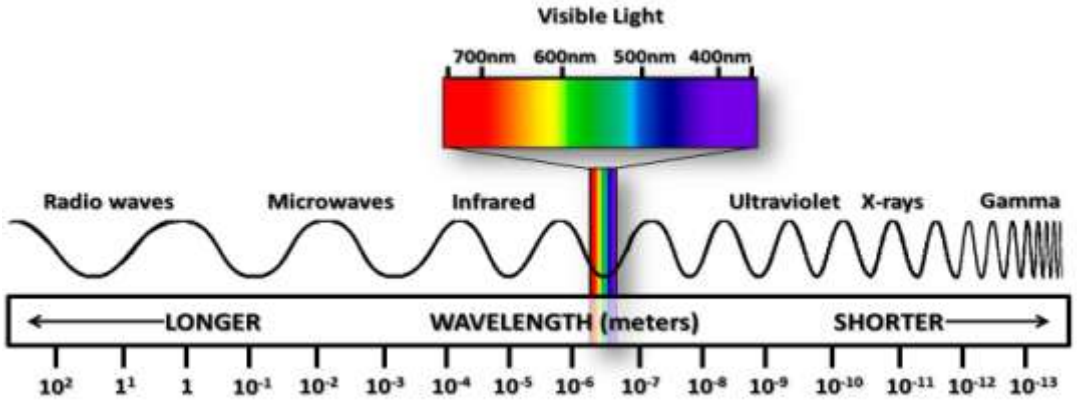

Fig 1.Electromagnetic Spectrum

This Prototype Discusses The Implementation Of The Basic *Li-Fi* Based Prototype For Transmission Of Sound Signal From Transmitter To Receiver With The Help Of Visible Light Communication. The Model Will Transmit Digital Signal Via Direct Modulation Of The Light On The Detector Which Detects The Signal At The Receiver Section. In Addition To The Operation, This Prototype Enables Investigation Into The Features Of The Visible Light And Leds Incorporated In The Communication Model.

II. Block Diagram

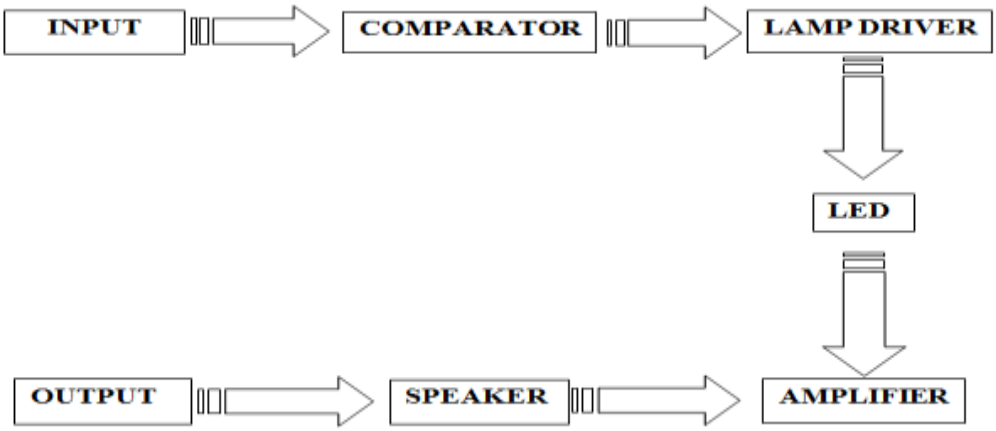

Fig 2. Block Diagram

1.1 Description

The Basic Block Diagram Consist Of

- Input From The Source
- Comparator
- Lamp Driver Leds
- Photo Detector
- Amplifier And Speaker
- Output At The Destination

2.1.1 Input

It Consists Of Analog Input Signal, Which Is Normally Transmitted From The Audio Output Of The Mobile Phone, Laptop Or Any Other Musical Instruments. Here We Make Use Of Light Emitting Diode (Led's). The Signal Transmitted Will Be A Low Level Signal Which Isn't Enough To Drive An Led, So In Order To Drive The Leds We Have To Amplify The Signal With The Help Of Amplifier.

2.1.2 Comparator

The Input Signal From Transmission Device Will Be At Low Level, So In Order To Modulate The Signal From The Led, We Convert The Signal In The Form Of Pulses. To Accomplish This Task We Use An Op-Amp Comparator Which Uses **Lm 358** Op-Amp Ic. The Comparator Compares The Transmitted Signal With The Help Of Reference Voltage And Generates An Output Signal Which Will Be In Pulse Wave Form. This Pulse Wave Is The Amplified And Passed To The Lamp Drive Of The Transmitter.

2.1.3 Lamp Driver

The Output Signal Transferred From The Comparator Has To Be Amplified To Drive The Leds. Modulation Of The Input Signal And Carrier Light Signal Do Takes Place Place At The Lamp Driver Using A Transistor Called **Bc 548**, Which Is Nothing But A General Purpose Silicon Transistor Which Is Used As Amplification Transistor As Well As Modulation Transistor. This Amplified And Modulated Signal Helps To Drive The Led. These Leds Transmit The Modulated Signals To The Receiver.

2.1.4 Leds

In *Li-Fi* Transmission, The Most Aspect Is The Ability To Turn On And Off Repeatedly In Very Short Period Of Time (In Ns Range). So We Make Use Of Leds Which Operates At Less Switching Time. These Leds Hops To On And Off Signal In Nano Second Based On The Pulse Signal Generated. Since The Switching Takes Place At Very High Transmission Rate, It Can't Be Possibly Detected By A Human Eye. So It Will Look Like Constant Illuminating Signal But Actually Switching From On & Off At Faster Switching Possibilities. Thus The Modulated Signal Is Then Transmitted To The Receiver Using Led Via Visible Light Communication.

Table 1. LEDs – Wavelengths and Applications	
LED Wavelength (Color)	**LED Applications**
410–420 nm (Violet)	Skin therapy
430–470 nm (Blue)	Dental curing instruments
470 nm (Blue)	White LEDs using phosphor, blue for RGB white lights
520–530 nm (Green)	Green traffic signal lights, green for RGB white lights
580–590 nm (Amber)	Amber traffic signal lights, amber for RGBA white lights
630–640 nm (Red)	Red signal lights, red for RGB white lights
660 nm (Deep Red)	Blood oximetry
680 nm (Deep Red)	Skin therapy
800–850 nm (Near-IR)	Night-vision illuminators and beacons for use with night-vision goggles or CCDs
850–940 nm (Near-IR)	Photoelectric controls
940 nm (Near-IR)	Covert illumination CCD-based systems

Table 2. Leds Wavelength And Applications

2.1.5 Photo Detector

The Transmitted Signal From The Leds Is Then To Be Detected At The Receiver Section. So In Order To Detect The Information Signal From The Blinking Led Light At The Transmitter, We Make Use Of Photo Cell Or A Photodetector (Which Comprises Huge Number Of Photo Cells Aligned In Series Formation). The Photodetector Detects Only The Light Formations. So Using Photocell We Could Detect And Demodulate The Message Signal Transmitted.

The Photodiodes Having A Good Responsivity To Visible Light Communication Are Actually Silicon P-Type Insulator & N-Type Photodiode (Si Apd).This Silicon Material Comprises Of A Photodiode Which Operates From 400nm To 1200nm, Including The Visible Wavelength Range. There Are N Number Of Photodiodes Whose Bandwidths Are Over 200 Mhz And Is Much Wider Than The Vlc Transmitter.

2.1.6 Amplifier And Speaker

The Signal Demodulation Will Be At Low Voltage Range. So It Is Then Amplified At A Particular Arbitrary Voltage Level Using An Amplifier. This Amplifier Will Also Be Of The Same Type Amplifier Which We Did Used In Transmitter Side. This Is Due To The Fact That If Any Phase Errors Are Detected, Then It Will Clear Thesignal At The Stage. The Speaker Will Then Transform The Received Electrical Signal To An Audiosignal Using Electro Magnets Present In The Speaker.

2.1.7 Output

This Audio Signal Is Then Transmitted From Speaker To Its Final Path. So That The Audience Can Hear The Message Loud And Clear That Has Been Transmitted From The Transmitter.

III. Circuit Diagram And Working

1.2 Transmitter

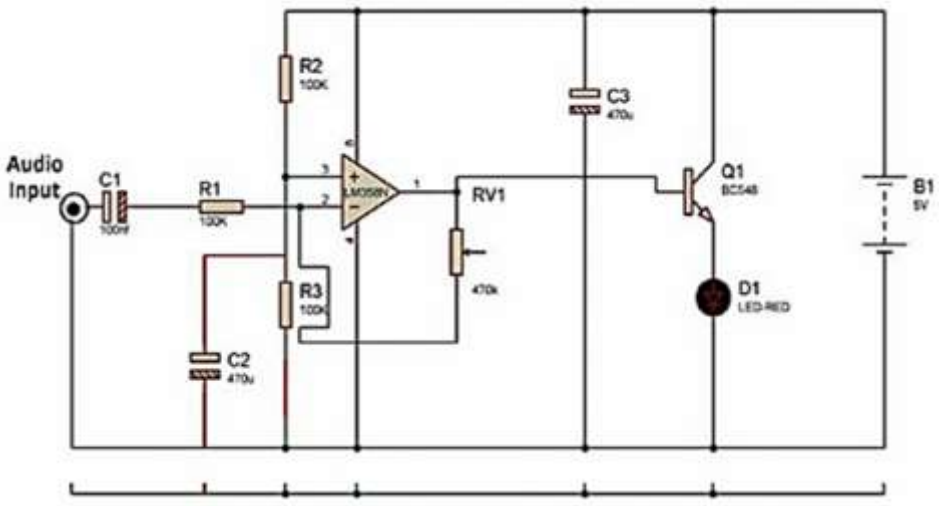

Fig 3. Circuit Diagram Of Transmitter

3.1.2 Working Of Transmitter

The Above Figure Shows The Transmitter Of The Prototype. We Know That Carrier Waves Can Take Signals Along Destination To Destination, So The Simple Concept Is When We Put Photons With High Speed In The Form Of Light From Source To Destination It Can Also Take Signals Of Low Frequency To Destination.

The Input Transmitted From An Audio Device Is The Input Whichwill At Very Low Audio Signal Frequency Of 20hz To 20 Khz. These Signals Then Paces Through Capacitor C1 (100nf) Where The Dc (Direct Current) Components Are Filtered And Vanished. Through R1 100kΩ And R4 100kΩ, Voltage Will Be At The Inverting Terminal Of The Op-Amp Whose Limit Is Kept At 5v/2 = 2.5v.

Input Signal At Pin 3 Of Op-Amp Is Compared With Pin 2 Of Op-Amp And Output Will Be Present At The Pin No 6 Of The Opamp Ic. Resistance Of 470kΩ Pot Or Feedback Gain Controller To Control The Volume At Output Of The Opamp. If There Is No Input Fed To The Comparator, There Is A Presence Of Positive Dc Wave At Pin 6 Of Op-Amp, Which Make Transistor Q1 Keep Alive And Led Starts To Transmit Signalcontinuously. The Capacitors C3, C4 (Both Are 470µf) Acts As Filters Help To Reduce Ac Components Arises In The Circuit.

The Comparator Compares The Input Signal With The Help Reference Voltage And Will Generate A Pulse Wave Signal At The Output Of Pin 6. The Width Of The Pulse Wave Is Controlled By The Input Signal Frequency. The Pulse Signal Is Equivalent To The On/Off Signal Which Controls The Intensity Of Light Source Aka Led (D1). The Pulse Wave Is Further Amplified And Modulated Using Transistor Bc548 (T1), Which Is An Amplifier Modulator Having High Current Gain. The Transistor Will Act As A Lamp Driver And Drives The Led. Since The Blinking Of The Led Is Controlled By The Transmitted Signal, It Will Take Place In Nano Seconds (Ns) Which Won't Be Detected By An Human Eye.

3.2 Receiver

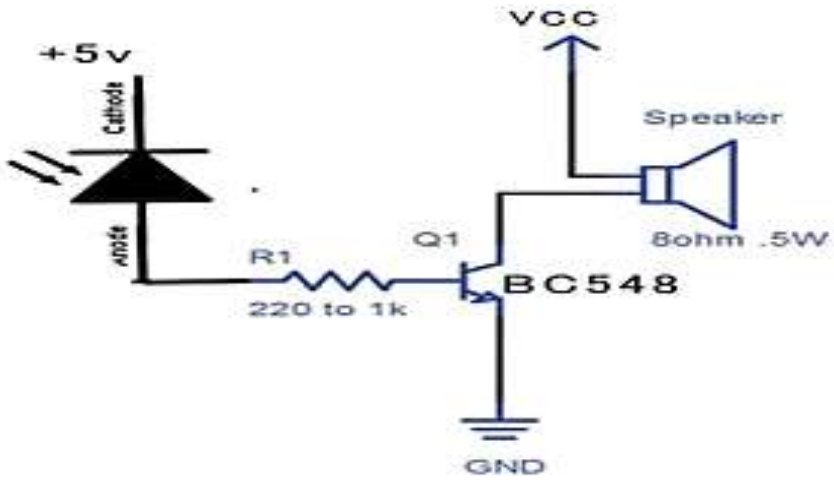

Fig 4. Circuit Diagram Receiver Circuit

3.2.1 Working Of Receiver

The Detectoror Photocell Is Used At The Receiver To Detect The Light Transmitted From The Leds. Which Then Produces An Analog Output Corresponds To The Input Signal. The Frequency Of The Analog Will Be Equal To The Input Signal, Since The Flickering Of Led Is Controlled By The Input Signal Which Detects Only The Fluctuation In The Led Signal And Produces The Output. It Also Helps In Eliminating The Phase Changes Which Occurs From The Transmitted Signal. The Amplified Signal Is The Transferred To The Speaker. The Speaker Then Converts The Analoginput Signal To The Audible Sound Signal Using The Electromagnet Present In The Speaker.

IV. Comparison Between Li-Fi And Wi-Fi

Li-Fi Is A Term Used To Describe Visible Light Communication (Vlc) Technology Applied To High Speed Wireless Communication Devices. It Acquires The Name Due To The Similarity In The Operation Of*wi-Fi*, Only Using Visible Light Instead Of Radio. *Wi-Fi* Is Great For Basic Wireless Connectivity Within Buildings, And *Li-Fi* Is Ideal For High Density Wireless Data Coverage In Confined Area And Is Used For Very Large Scale Applications.

Parameter	Wireless Technology	
	Li-Fi	**Wi-Fi**
Speed Of Transfer	Fast Transfer Speed(>1gbps)	Data Transfer Speed(150mbps)
Data Density	Higher Compared To Wi-Fi	Lesser Compared To Li-Fi
Spectrum Range	Visible Spectrum	Radio Spectrum
Cost	Cheaper Than Wi-Fi Because Free Band Doesn't Need License	Expensive Than Li-Fi As It Uses Radio Spectrum
Network Topology	Point To Point	Point To Point
Operating Frequency	Hundreds Of Thz	2.4ghz
Obstacle Interference	Affected By Obstacles	Less Affected By Obstacles
Security	Secure As Light Does Not Penetrate Wall	Less Secure Compared To Li-Fi
Range	Smaller Range	Wider Range

Table 2. Comparison Between Current And Future Wireless Technology

V. Analysis And Result

In Our Project We Have Designed And Implemented A Wireless Communication Device Which Transmit Audio Message Wirelessly With The Help Of Visible Light Such A Phenomenon Is Known As Light Fidelity (*Li-Fi*). The Project Contains Two Sections 1 – Transmitter Section And 2 – Receiver Section. The Transmitter Section Modulate The Incoming Message Audio Signal And Transmit Towards The Receiver With The Help Of Led In The Form Visible Light. The Receiver Section Then Interprets The Incoming Light Which Is Also Detected By Using A Photodetector Which Converts To Desired Audible Sound Signal With The Help Of Speaker.

1.3 Advantages

Li-Fi Technology Is Based On Leds Or Other Light Source For The Transfer Of Data. The Transfer Of The Data Can Be With The Help Of Light, No Matter The Part Of The Spectrum That They Belong. That Is, The Light May Belong To The Invisible, Ultraviolet Or The Visible Part Of The Spectrum. Also, The Transmission Rate Of The Communication Is More Than Sufficient For Downloading Movies, Games, Music At A Short Period Of Time. Also, *Li-Fi* Removes The Drawbacks That Have Been Put On The User By The *Wi-Fi*.

5.1.1 Capacity

Light Has 400 Times Wider Bandwidth Than The Present Radio Waves In The Electromagnetic Spectrum. Also, Light Sources Are Already Being Installed In Our Surroundings From Years Before. So, *Li-Fi* Has Got Better Capacity And Also The Infrastructures Are Already Available.

5.1.2 Efficiency

Data Transmission Using *Li-Fi* Is Very Cheap And Requires Less Consumption. Led Lights Consume Less Energy And Are Highly Efficient And Long Lasting.

5.1.3 Availability

Availability Is Not A Problem Faced As Huge Number Of Light Sources Are Present Everywhere. There Are Billions Of Light Bulbs Fixed Worldwide, That They Just Need To Be Replaced With Leds For Proper Transmission Of Data.

5.1.4 Security

Light Waves Do Not Penetrate Through Walls. So, They Can't Be Intercepted And Misused. Therefore, There Is No Security Issues Faced In Li-Fi.

5.1.5 No Limit For Connectivity

The Capability Of Transferring High Speed Data Through *Li-Fi* Ensures That Large Number Of Users Can Be Connected, Since Speed Will Not Be Throttled Or Slowed Down.

5.2 Limitations

Thereare Some Major Limitations Of This Technology Are

5.2.1 *Li-Fi* Cannot Penetrate Through Walls

The Artificial Light Used Cannot Penetrate Throughwalls And Other Opaque Matters Which Radio Waves Are Capable Of Doing. So A *Li-Fi* Enabled End Device (Through Its Inbuilt Photo-Receiver) Will Never

Be As Fast And Handy As A *Wi-Fi* Enabled Device If Any Obstacle Gets Into A Way While Transmission Or Reception.

5.3 Applications

There Are Plenty Of Applications Of This Technology, From Internet Access Around Our Surroundings Through Street Lamps To Auto-Piloted Cars That Communicate Through Their Headlights. Applications Of *Li-Fi* Can Be Extend In Areas Where The *Wi-Fi* Technology Does Not Entertain Its Presence Like Medical Technology, Power Plants And Various Other Areas. Since Li-Fi Just Make Use Of Visible Light, It Can Be Used Safely In Aircrafts And Hospitals Where Wi-Fi Technology Is Banned Because The Transmission Of Rf Are Prone To Interference.

Some Of The Future Applications Of Li-Fi Are As Follows:

5.3.1 Education Systems

Li-Fi Is The Latest Technology That Can Provide Maximum Speed Internet Access And Vast Internet Connectivity. So, It Can Replace *Wi-Fi* At Educational Institutions And Also At Companies Where The Users Can Make Use Of *Li-Fi* With The Same Speed Intended In A Particular Area.

5.3.2 Medical Applications

Operation Theatres (Ots) Do Not Allow Wi-Fi Connection Due To Harmful Radiations. The Usage Of *Wi-Fi* At Hospitals Interferes With The Mobile And Personal Computers Which Blocks The Signals For Monitoring Equipment's. So, It May Be Tremendously Dangerous To The Patient's Health. To Overcome This And To Make Operation Theatre Tech Savvy *Li-Fi* Can Be Used To Accessing Internet And To Control Medical Equipment's. This Can Even Be Beneficial For Robotic Surgeries And Other Automated Procedures.

5.3.3 Applications In Sensitive Areas

Power Plants Need Fast, Inter-Connected Data Systems So That Demand, Grid Integrity And Core Temperature (In Case Of Nuclear Power Plants) Can Be Monitored Easily. *Wi-Fi* Do Have Many Other Radiationswhich Are Bad For Sensitive Areas Surrounding The Power Plants. *Li-Fi* Offers Safe, Fast Connectivity For All Areas Of These Sensitive Locations. This Can Also Save Money As Compared To The Currently Implemented Systems. Also, The Pressure On A Power Plant's Own Reserves Could Be Less Compared To The Present Scenario. *Li-Fi* Can Also Be Used In Petroleum Or Chemical Plants Where Other Transmission Or Frequencies Could Be Hazardous And May Cause Damage To The Surroundings.

5.3.4 Replacement For Other Technologies

Li-Fi Does Not Make Use Of Radioactive Waves. So, It Can Be Easily Used In The Places Where Bluetooth, Infrared, Wi-Fi Etc. Are Usually Banned And Are Strictly Offensive.

VI. Conclusion

The Possibilities Are Numerous And Can Be Explored Further. If This Technology Can Be Put Into Some Practical Applications, Every Bulb Can Be Used Something Like A *Wi-Fi* Hotspot Device Or To Transmit Wireless Data.And We Would Proceed Toward The Cleaner, Greener, Safer And Brighter Future.

The Concept Of *Li-Fi* Is Currently Grabbing The Attention To A Great Extent, Not Least Because It May Offer A Genuine And Very Effective Alternative To Radio-Based Wireless Communications. As A Growing Number Of People And Their Many Devices Access Wireless Internet, The Airwaves Are Becoming Increasingly Clogged, Making It More And More Difficult To Get High Reliability. By Using *Li-Fi* We Canalso Save A Lot Of Energy.

In Future, We Can Have Led Arrays Beside Highways Helping To Light The Road, Displaying The Latest Traffic Updates Regarding The Traffic Issues And Transmitting Internet Information Wirelessly To Passengers Laptops, Notebooks And Smart Phones And To Other Devices. This Is The Kind Of Extra Ordinary, Energy Saving Parallelism That Is To Be Delivered By This Growing Technology.

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