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A Novel Navigation System using Light Fidelity (Lifi) Technology

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Abstract: Lifi is a wireless optical networking technology that uses light emitting diodes (LEDs) for data transmission. In this project, a novel navigation system for highways and remote areas is designed by using Lifi technology. The light fidelity technology refers to visible light communication that uses light as a medium to deliver high-speed data in a manner which is much greater than that of Wifi. The transmission of data is done using visible light through LED bulbs in street lights and reception of data (Ex. Location) on receiving device (i.e., LDR sensor). The system consists of two units i.e., the transmitter unit and the receiver unit. The transmission unit consists of street lights that have microcontrollers with previously stored data. As soon as a vehicle comes in range of visible light of these poles, it transmits data to that vehicle. The available information gets displayed on the LCD installed with receiver in the vehicle. This device will provide the information to the travellers about present location. As this technology uses LED's for data transmission, it is fast and more secure compared to other wireless technologies, and can transmit data at very higher speeds.

I. INTRODUCTION

The general term visible light communication (VLC), includes any use of the visible light portion of the electromagnetic spectrum to transmit information. The term Lifi was coined by Harald Haas from the University of Edinburgh in the UK. The D-Light project at Edinburgh's Institute for Digital Communications was funded from January 2010 to January 2012. Haas promoted this technology in his 2011 TED Global talk and helped start a company to market it. Pure VLC is an original equipment manufacturer (OEM) firm set up to commercialize Lifi products for integration with existing LED-lighting systems. He is the co-founder of "PureLifi" with its legacy products like Li-1st, Li-Flame and Lifi-X.

Lifi, or "Light fidelity", refers to wireless communication systems using light from light-emitting diodes as a medium instead of traditional radio frequencies, as in technology using the trademark Wi-Fi. Lifi is expected to be ten times cheaper than Wi-Fi. Lifi has the advantage of being able to be used in electromagnetic sensitive areas such as in aircraft and nuclear power plants without causing interference. The light waves cannot penetrate walls which makes a much shorter range, though more secure from hacking, relative to Wi-Fi. Lifi is a technology that uses light for data transmission. Unlike Wifi that uses radio waves, Lifi uses light. The visible light spectrum is 10,000 times larger than the entire radiofrequency spectrum. Researchers have reached data rates of 3.5 Gbps and have set a goal of reaching 6 Gbps. The Lifi market is projected to be worth over $6 billion per year by 2018.

Optical wireless technologies are at times also called as visible light communication (VLC) and more recently referred to as Lifi (Light Fidelity), which offer an entirely new model in wireless technologies in terms of communication speed, usability, and flexibility. Lifi acquired this name due to resemblance to Wifi, using light instead of radio waves. Lifi (light fidelity technology) is the recent technology that emerged in the field of wireless communication. This technology provides visible light communication (VLC) which sends the data by flashing the light at speeds undetectable to human eyes. The LED lights used in Lifi are cheap, durable, and secure and provide good performance. VLC is free of any health concerns, as it uses eco-friendly green technology rather than microwaves, which can cause harm to the human body. The VLC systems use LED to send data by flashing light at speeds undetected to human eyes.

II. LITERATURE REVIEW

"Lifi:Wireless Communication Media", Prof. Amit Mishra [1], has developed application module of Lifi technology, where data is transmitted through LED and is received by photodiode. The transmitter section consisted of microcontroller, temperature and gas sensor to detect smoke and temperature of room in case if an accident occurs. The received data is displayed on LCD with the help of device driver.

"A Comparative Study and Analysis on Lifi and WiFi", Ashmita Shetty [2], performed a comparative study and analysis of Lifi and Wifi. By implementing a Lifi system using white Led light bulbs, which were used for illumination by applying a constant current.

However, by fast and subtle variations of the current, the optical output can be made to vary at extremely high speeds. The results showed that both these technologies are used for the data connection but there are some drawbacks of Wifi which can be reduced by the emerging technology that is Lifi.

"Lifi Based Indoor Navigation System for College", Avinash Kumbhar, Praful Wadkar , Mayur Virkar & Shubham Bhalekar [3], has proposed a Lifi based indoor navigation system for college. This approach provides organized way to find particular destination within college premises. They have used Lifi module. The data is transmitted to server through Lifi, server will fetch the required data from database and the data is sent to user through Lifi. This is efficient technique for searching location. This method can be extended to make each bulb to become Wifi hotspot to transmit wireless information.

"An Approach towards High Speed Communication Using LIFI Technology", Aishwarya Hamand [4], described the prototype was designed to achieve the output in the form of audio and data. 1. Audio transmission-Transmitter consisting the audio signal from the mobile phone as an input which connect through the audio jack and this audio signal will convert to analog signal through DAC. At the receiver which consists solar panel which detects the LED information generates the waveform voltage which is then amplifies with speaker and we get the output audio signal on the speaker. 2. Data transmission-The transmitter consists of text as an input and by using Terminal Software the text will be converted to ASCII information and by setting the baud rates range transmission speed was varied. At the receiver side the threshold is set by comparator as 0 & 1 (digital), and the output is obtained on another pc.

"Survey on LIFI technology and its applications", Hema Patel [5], in survey on Lifi technology described about 'Security' of Lifi. Li-Fi provides greater number of available access points, as each source of light provides full channel data rates with fewer simultaneous users. Li-Fi provides benefit of 1000 times greater speed to each user. In addition, and in contrast to radio waves, the light does not pass through the walls. Therefore, with minimal precautions to avoid leakage from windows, doors, etc., security is fundamentally enhanced as compared with Wifi.

"High speed visible light communications systems", Liane Grobe [6], worked on a bidirectional real-time VLC prototype achieving data rates of up to 500 Mb/s. This system paves the way for future real world applications .The experiments demonstrates for the first time that the dense optical Wifi communication can be used in a reasonable indoor setup using commercially available hardware. He used red LED sources for better visualization of the bidirectional data transmission. The experimental results showed that any other high-power LED could be used as the light source regardless of its color to provide necessary analog bandwidth and data rates.

"A Review on LI-FI: Data Transmission through illumination",Renu Kalakoti and Pranita Nehete[7], made a relative study on Lifi, its need and future scope. With the advent of semiconductor technology this field has gained importance. The VLC uses off-the-shelf white light emitting diodes as signal transmitters and off-the-shelf p-intrinsic-n (PIN) photodiodes (PDs) or avalanche photodiodes (APDs) as signal receivers. Lifi is optical version of Wifi, which helps in broadcasting of network. Large scale areas that are saturated with RF signal could use Lifi as alternative high speed network.

Highway Navigation System using Light Fidelity Technology", Shruti Srivastava and Shivam Bhardwaj[8], describes about Navigation application of Lifi technology. Transmission and Reception of information takes place in form of light energy which is used for navigation on highways. The idea of transmitting using the visible light spectrum allows light to modulate at fast rate so that can be picked by receivers equipped with light sensors at very high speeds of hundreds of megabytes per second, enabling the light source to transmit data. The results obtained can be utilized to replace radio based wireless technologies. This technique could result extremely beneficial in managing traffic and thereby setting up a "Smart City".

"Data Communication using Visible Light", Prof. Smita Pawar [9], demonstrated how to use visible light as a medium to transmit data such as music and text. By replacing huge hardware modules with programmable Arduino boards have reduced the size of setup and made it more versatile. By using simple signal processing hardware attached to LED bulbs can be used to supplement data consumption. It has become more practical to implement and use in daily life and proved that Visible Light Communication is a cleaner, greener, cheaper and safer way of communicating.

"Lifi Technology, Implementations and Applications", Yash Khare [10], demonstrates technical aspects of Lifi communication that is modeled after protocols established by the IEEE 802 workgroup. It defines physical layer (PHY) and Media Access Control (MAC) layer for VLC/Lifi. The MAC layer supports 3 multiaccess technologies: peer-to-peer, star configuration and broadcast mode. The modulation schemes such as On-Off keying (OOK), Color shift keying (CSK), Variable Pulse Position Modulation (VPPM) etc have been studied with regard to Lifi. He concluded that Modulation and Demodulation techniques are also very important for the signal that is involved in communication

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III. METHODOLOGY

In our proposed prototype, we have microcontrollers at both the transmitter and receiver end. The data is previously converted into 0-1 format before being fed to the microcontrollers. The microcontroller at the transmitter side has the data regarding the area in which the street light is installed, programmed in it. We have 3 such street light poles with different data of current position and left and right turn. The series LED (Light emitting diode) of each street light pole is used as a transmitter for transmitting the data. At the receiver side, we have a LDR (Light dependent resistor) module with microcontroller to process the received data i.e., sensed by LDR sensor placed on the vehicle whose position is to be known. The vehicle is moved across the three poles to such that the receiver tracks the respective positions and the detected signal further passes to the microcontroller which converts the light into data and consequently the information of the present location is displayed on the LCD which placed in the vehicle. The basic main components involved in this project are the transmitter unit and the receiver unit. LED is used for transmitting the signal and LDR is used for reception purposes.

A. System Design

The whole system is break into two sections, first transmitter section and other one is receiver section.

1) Transmitter Unit

a) Arduino Nano: Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino microcontrollers are pre-programmed with boot loader that simplifies uploading of programs to the on-chip flash memory. In our prototype, the Arduino microcontroller is loaded with program code of the information about the current position via a serial connection to computer.

b) Light Emitting Diode (LED): The series LED help in transmitting the information. They flicker at a faster rate so that the code in the form of 0s and 1s reaches the receiver.

c) Voltage Regulator: To generate a steady output voltage of a circuit in response to variations in an input voltage conditions, we require a voltage regulator. We might have 9V in, but if we want only 5V out, then we need to step it down (Buck) with a voltage regulator. In our project, we have used a single trimmer buck converter for voltage regulation purpose in the transmitter.

d) Tip122 Darlington Transistor: The TIP122 is a Darlington pair NPN transistor. It functions like a normal NPN transistor, but since it has a Darlington pair inside it has a good collector current rating of about 5A and a gain of about 1000. It can also withstand about 100V across its collector- Emitter hence can be used to drive heavy loads.

e) Screw Terminal: A screw terminal is a type of electrical connector where a wire is held by the tightening of a screw. Here it is used to connect series LED to the main circuit.

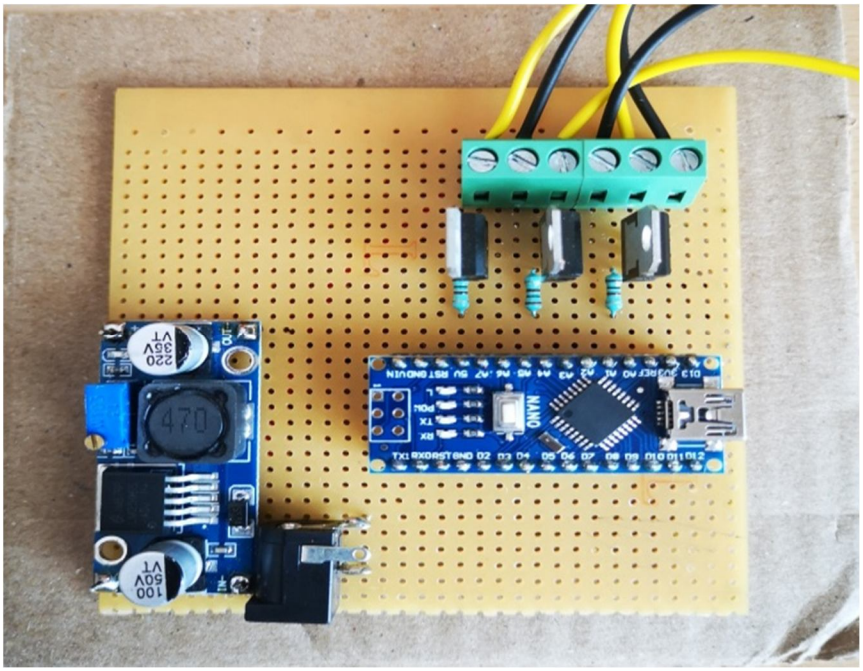

Figure 1 Transmitter Unit

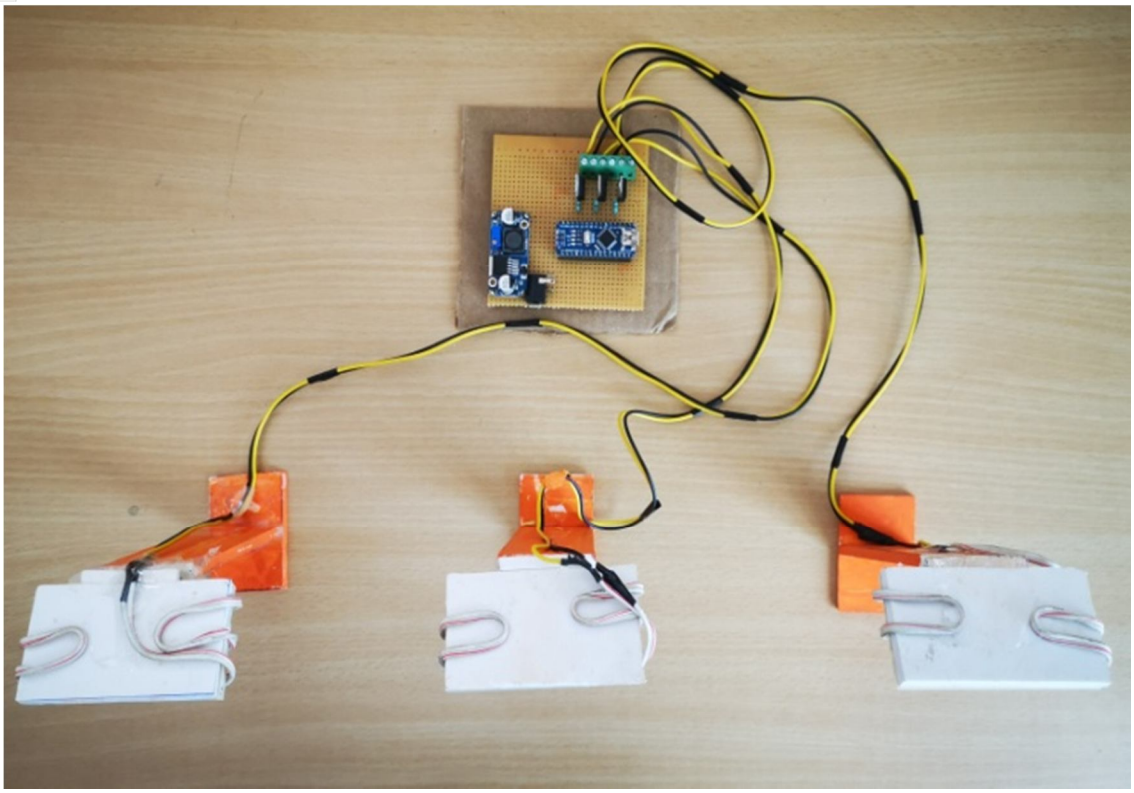

Figure 2 Transmitter Unit (Complete Setup)

2) Receiver Unit

a) Photo Resistors: In the prototype, we have used a Light Dependent Resistor (LDR) for photo detection. An LDR is a component that has variable resistance which changes with the change in intensity of the light that falls upon it and it exhibits photo-conductivity. Thus, LDR can be used in light sensing circuits.

b) Liquid Crystal Display: In the prototype we have used a LCD display which displays the current position of moving vehicle. The LCD has two registers, namely, Command register (to insert a special command into the LCD) and Data register (to insert a data in LCD).

c) Buzzer: A buzzer is a tiny speaker that is connected directly to an Arduino. It makes the sound when a particular position is reached by the vehicle.

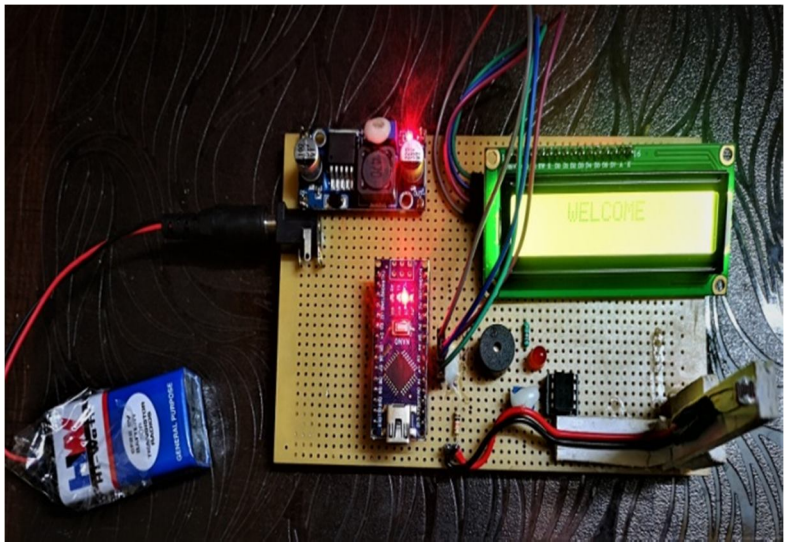

Figure 3 Receiver Unit

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B. Circuit Connections

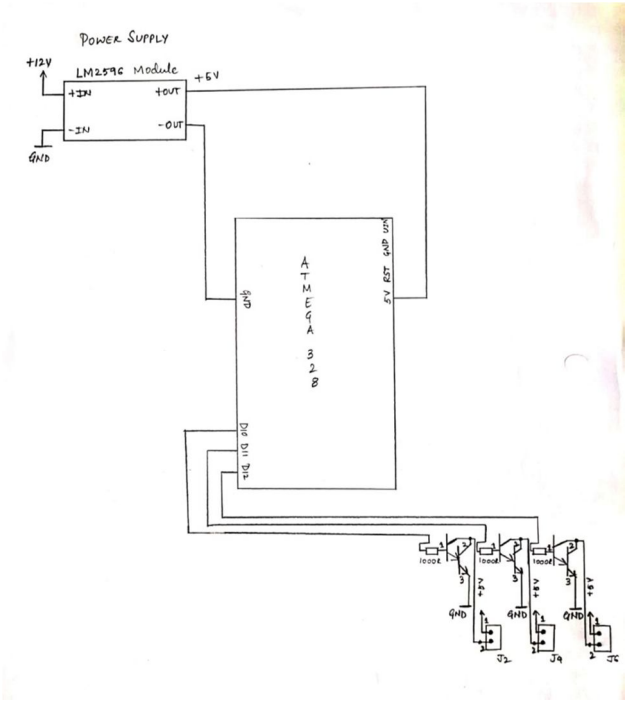

Figure 4: Circuit diagram (Transmitter Unit)

Circuit connections for Transmitter Unit as shown in figure 4 - GND and 5V pins of Arduino 328P microcontroller are connected to -OUT and +OUT of Voltage regulator. Pins D10, D11 and D12 are connected to Tip122 Darlington transistors through 1000 ohms resistor. The transistors are in turn connected to the screws of plastic pole screw terminal.The positive and negative terminal of series LED is connected to screw terminal.

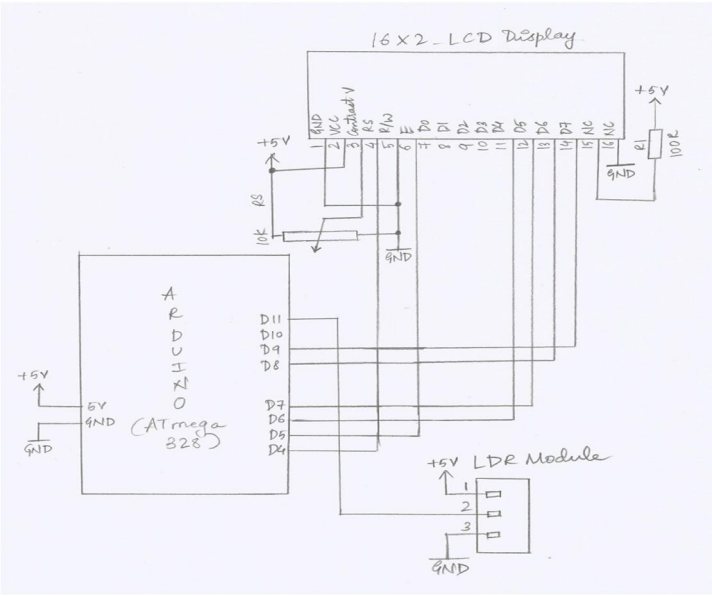

Figure 5: Circuit diagram (Receiver Unit)

Circuit connections for Receiver Unit as shown in figure 5- GND and 5V pins of Arduino 328P microcontroller are connected to -OUT and +OUT of Voltage regulator. Pin D11 is connected to Pin 2 of the LDR module Pins D4, D5, D6, D7, D8 and D9 are connected to RS, E, D4, D5, D6, D7 of LCD display.

IV. RESULTS AND DISCUSSION

Outputs- We conduct test based evaluation on our prototype. We notice that as soon as the receiver (vehicle) comes in the range of any of the Poles labelled 1, 2 and 3. The LDR sensor on the receiver senses the light from the Pole. Each Pole has separate position information which is to be displayed on LCD display as shown the table 1.

POLES	POSITION	LEFT SIDE	RIGHT SIDE
1	MG Road	Sec 18	Sec 17
2	Library	E BLK	F BLK
3	Malviya Ngr	Saket	CLOSED

Table 1. Outputs

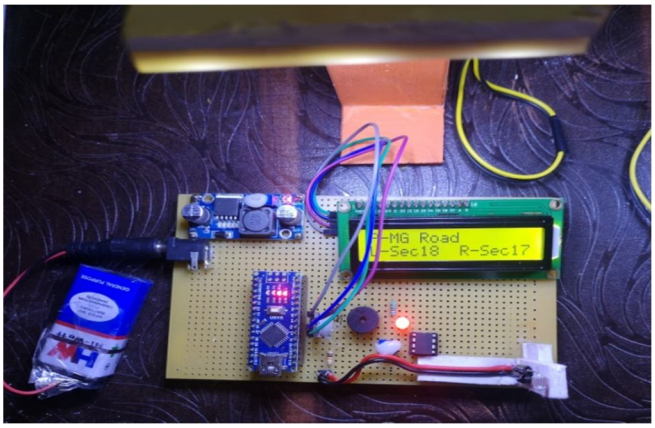

Figure 6: Position at Pole 1

In fig.6, shows the position as MG road and the left side and right side as Sec 18 and Sec 17 respectively. This is obtained when the receiver unit is below Pole 1.

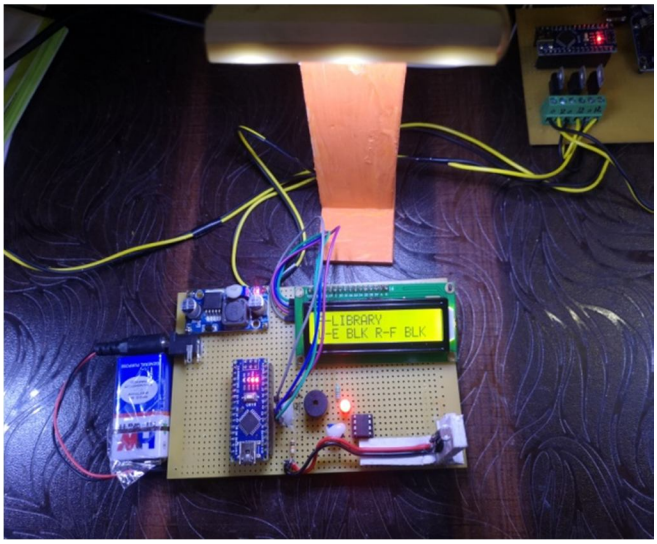

Figure 7: Position at Pole 2

In fig.7, shows the position as Library and the left side and right side as E BLK and F BLK respectively. This is obtained when the receiver unit is below Pole 2.

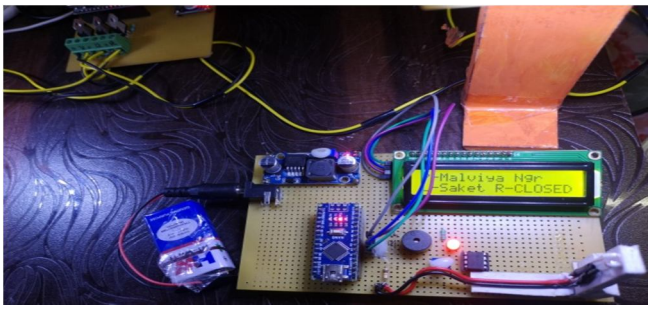

Figure 8: Position at Pole 3

In fig.8, shows the position as Malviya Ngr and the left side and right side as Saket and CLOSED respectively. This is obtained when the receiver unit is below Pole 3.

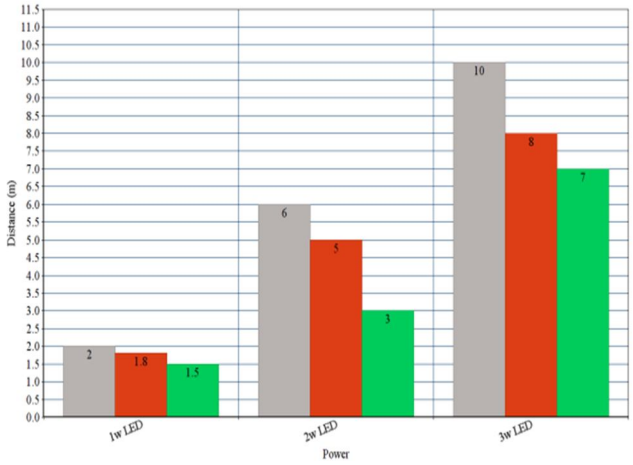

Figure 9: Comparison of different LEDs and distance travelled by light ray under different

From the above working we have obtained these results. Here the distance of the reach of the light varies according to its environment such as fog, Smog, dust, etc. We have tested with 3 different cases as with Clear path of sight, Fog in path of sight, Dust in path of sight for different watt LEDs and obtained the results as shown in figure 9.

V. APPLICATIONS

1) *Airways*: Whenever we travel through airways we face the problem in communication media, because the whole airways communications are performed on the basis of radio waves. To overcome this drawback on radio ways, Lifi can be introduced.
2) *Medical*: For a long time, medical technology has lagged behind the rest of the wireless world. Operating rooms do not allow Wi-Fi over radiation concerns, and there is also that whole lack of computers cans block signals from monitoring equipment. Lifi solves both problems: lights are not only allowed in operating rooms.
3) *Increase Communication Safety*: Due to visual light communication, the node or any terminal attach to our network is visible to the host of network.
4) *Multi User Communication*: Lifi supports the broadcasting of network; it helps to share multiple things at a single instance called broadcasting.
5) *Smarter Power Plants:* Wi-Fi and many other radiation types are bad for sensitive areas. Like those surrounding power plants. But power plants need fast, inter-connected data systems to monitor things like demand, grid integrity and (in nuclear plants) core temperature. The savings from proper monitoring at a single power plant can add up to hundreds of thousands of dollars. Lifi could offer safe, abundant connectivity for all areas of these sensitive locations.

VI. CONCLUSION

In this project, a Novel Navigation System using Lifi was proposed and the remote prototype was built. The main aim of the project was to eliminate the need for mobile networks in remote areas. A small chip fit into the potential illumination device gives it lightning as well as information about the current location of the vehicle. It will be transmitted through the LEDs installed in street lights and will be displayed to the receiver, this makes it convenient even if there is no mobile network. This technique could result in extremely beneficial as the light is widely available and thereby setting up a smart city.

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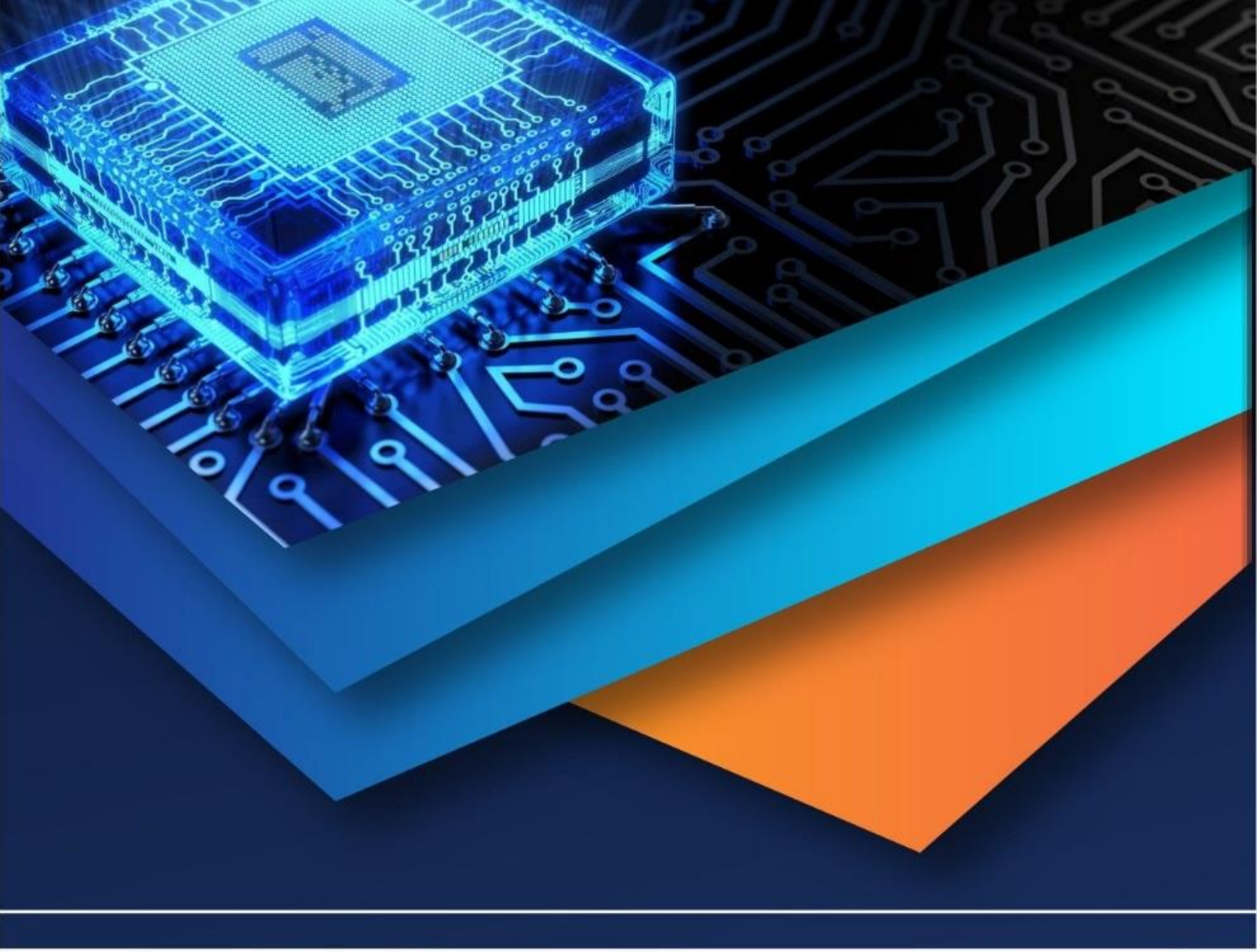

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