Implementing Visible Light Communication in Intelligent Traffic Management to resolve Traffic Logjams

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Abstract

Véhiculer Traffic is an inevitable phenomenon which is directly linked with the urban developmental society and cannot be ignored as it acts as a nervous system to the society in general and individuals in particular. Urban Traffic is emerging as an incurable threat to the modern society as there is a lack of efficient intelligent traffic management system. Prior attempts to use radio frequency spectrum, ultrasonic sensors and other alternatives proved to be ineffective as they are becoming crowded, that forced to develop an alternate means like wireless communication which can accommodate the exponentially increasing traffic demand. In this proposed research initiative, a Visible Light Communication (VLC) system is analyzed on its capabilities to provide an alternative to the current standards of wireless transfer of information using light from LEDs as the communication medium. The proposed system based upon the blinking of light-emitting diodes at a rapid rate such that the human eye will not notice the change in light illumination but a highly sensitive photodiode can read the behavioral changes and decode the information embedded within it. The proposed VLC methodology is also being tried to get implemented in intelligent wireless traffic management to resolve traffic logjams that usually occur in metro cities.

Keywords: photodiode, optical communication, LED, infrared, visible light, traffic management, wireless, etc

I. Introduction

The Real time traffic situations in metro cities are passing through their worst case scenario as there are millions of vehicles running every day in metro cities resulting in traffic nuisance and logjams and ultimately lowering the speed of life and add on the worries for the government too as it tends to cause a lot of delay in transportation of essentials cum commuters.

The main intension behind Visible Light Communication driven Intelligent Traffic Management System remains the finding of an efficient way of handling traffic inflow and outflow throughout a city so as to avoid harsh traffic jams and to prevent the creation of traffic in first place. As accordance with Human intelligence combining and latest technology, the proposed initiated system can revolutionize traffic management with the infrastructure already in place and minimal monetary requirements as in this system implementation of the existing light poles and Infrared (IR) sensors act as communication nodes in distinctive vehicles that can warn each other of a developing traffic situation and hence can prevent heavy traffic jams in prior to its happening.

Proposed initiative is composed of a transmitter which is a street light which transmit map information required to crossing vehicles and transfer the map information to each receiver installed in vehicles. In this system, every street light is having their differentiable unique Identifications (IDs) for the generation of a visible light signal to transmit the map information by using a Visible Light Transmitter module. Every mobile terminal installed in vehicle is equipped with a Receiver module for receiving the mapped information generated from the street light in visual light form and displays this fabricated information in the mobile terminal.

Apart from street lights, IR based vehicle motion detectors are implemented on both sides of the road which activates when any vehicle interrupts, the IR sensor gets activated and a jam signal, say "X" is sent by the vehicle to neighboring vehicles behind it, thus intimating them of the upcoming traffic situation ahead.
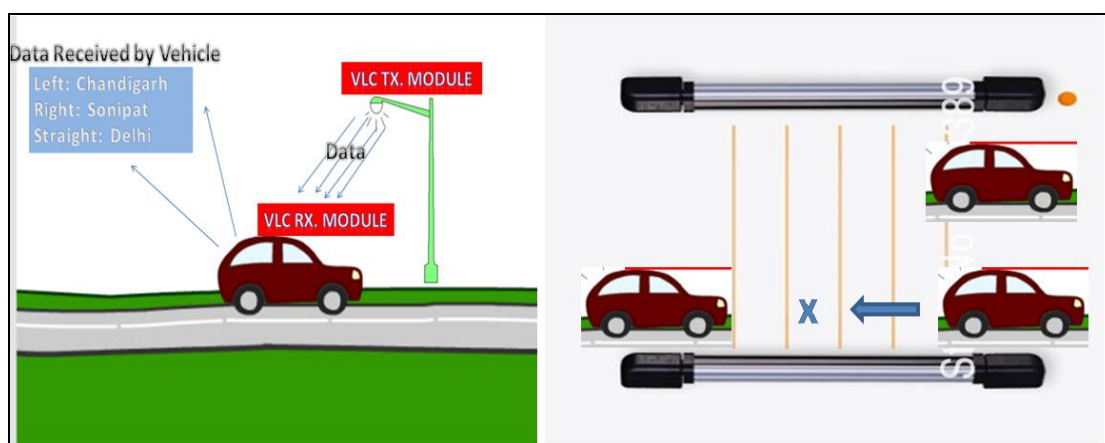

Fig: Direction and Traffic information

The theme of this research initiative encircles the infusion of Visible Light Communication and Traffic Management. The possibility of infusion of the both is being done through designing our own analog circuit to integrate with a computer, and then sending some form of data using visible light LEDs from a transmitter and decoding it with a receiver also implementing the principle of IR motion seekers that work through an emitter side which transmit a beam of invisible IR rays and receiver, installed at the opposite edge which is sensitive only to IR rays and detect vehicle passersby when the beam gets broken. The information then transmitted by blinking LEDs as bits and gets decoded by the photodiode installed in vehicles and signals them to maintain distance or to speed up accordingly. The proposed system is best suited to all those metro cities where the existing traffic management system proved to be failure due to over increasing traffic quantity and density.

II. Literature Review

Light Emitting Diodes, used in Visible Light Communication, is an eminent technology being researched and invented recently to be used for common communications systems such as traffic management, wireless data transmission, etc. Use of LEDs in VLC gives numerous advantages, one of which is long life expectancy and accuracy. However, unlike many emerging technologies, the VLC also has some techno-economical-feasibility issues which need to be addressed.

The LED based VLC system can operate in power economic perspective and has a longer life-time compared to the Compact fluorescent lightning devices and that is the reason why in this research initiative, the characteristic of short transient time in turning the light on/off processes was further investigated and a high-speed wireless communication system, which is embedded in our LED lighting system, was tried to be built. In this review, previously conducted credible researches are being scrutinized to understand their strength and weaknesses.

A. H. Elgala, et. all, In his research initiative proposed the differences between Radio and Visible Light Communication and declares that Optical Wireless Communications itself consists a long history of development and research. World wide deployment of solid state lighting (SSL) using LEDs is promoting to drive the proposed technology in the form of Visible Light Communication system. Received Data through an experimental system shown that the data density of $00.41 b/sec/Hz/m^2$ is being achieved from a VLC implementation.

S. Rajbhandari, S. Hashemi, et. all, In their research proposed a number of modulation techniques and thoroughly analyzed in literature for optical wireless communication system. Every modulation methodology has its attractive features as well as its shortcomings. There has been an important work on the analysis of these and many other modulation and demodulation techniques under distinct channel and environmental conditions.

C. HU Guo-yong and their colleagues in their research paper conclude the probability of visible red light laser being used as signal light source for Free-Space Optical (FSO) communication and on the basis of their analysis of transmission in atmospheric channel containing 650 nm laser beams, performance of wireless laser

communication link and a low power red laser diode was evaluated. Their proposed system was capable to achieve maximum range of 300 m at data rate 100 Mb/s on paper. A phenomenal short-range link at data rate 10 Mb/s covering 300 m is also going to be implemented in their university.

It remains feasible to increase the system performance such as link range and data rate by increasing transmitting power and decreasing laser beam divergence angle or through other approaches.

A. Mishra and Neelesh, and their colleagues in their findings gave the idea of using internet using Visible Light Communication and also said that wireless communication is the futuristic technology which will keep on spreading worldwide. In the present scenario, there is an immediate urgency for the improvisation in the means of connecting. A Wireless network using VLC is a new technical initiative that can easily pave the way for a comfortable wire-free future of internet as well as transmission and communication means. Such a technology is useful to establish a smart wireless network grid, underwater communication grid along with mobile services. Their research aims to explain the phenomenon of VLC through its application to provide Wireless Internet.

III. Principle

The **Visible light communication** is a data communication medium which employs visible light, ranging between 400-800 THz (usually 780-375nm) and acts as an alternate to optical wireless communications technologies.
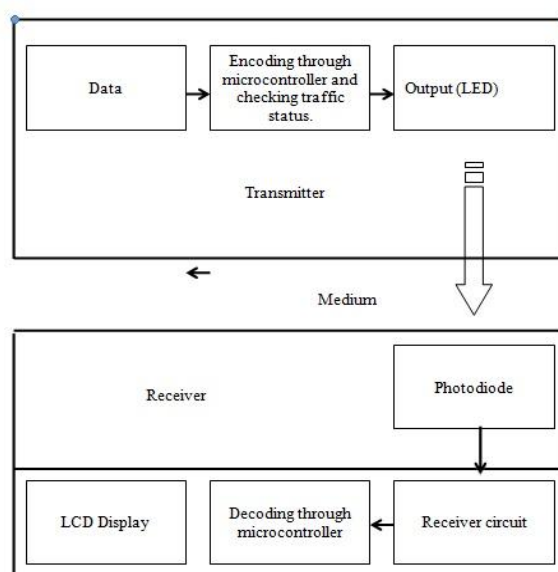

Fig: Block Diagram

In the proposed research initiative, visible light communication in achieved by switching LEDs on and off at a speed higher than is perceptible to human eye. Eyes are organs that can detect changes in light brightness and power when these changes occur over a long time scale, but they can not percieve light that is switched on and off rapidly, say at 200Hz or more depending on the eye. A photodiode on the other hand can easily recognize the rapid on-off modulation. A photodiode is a photodetector that produces an electrical current that is proportional to the optical power that is incident on the photodetector surface.

In this research, the above said principle is used to describe the implication of VLC in intelligent traffic management with the help of LEDs as a transmitter and vehicle installed photodiodes as a decoder and receiver. AVR Studio is used here as a development tool for the AT90S Series of AVR microcontrollers and embedded technology is used for circuit development & fabrication.

IV. Methodology

The system consists of transmitter & Receiver circuits in which transmitter circuit contains ATMEL ATMega16L microcontroller, BC 547 push – pull amplifier pair, LM 7805 Voltage regulator, LEDs, resistances and capacitances. Programmed Controller ATMega16L here acts as a central processing unit which encodes the data and feeds it to the LEDs via push – pull amplifiers. The voltage supplied to the LEDs fluctuates and flickers. This flickering is invisible to the human eye.

In the receiver side, ATMEL ATMega16L microcontroller, a photodiode, an LCD display, LM 7805 Voltage Regulator, BC 547 Transistor, resistances and capacitances are installed suitably to make the system complete and functional.

A photodiode consisting of p–n junction and when a photon of required charge encounters with the diode, it creates an electron-hole pair and generate inner photoelectric effect. The overall current through the photodiode remains total of the dark current and the photo-current that means dark current must be standardized to maximize the sensitivity of the device.
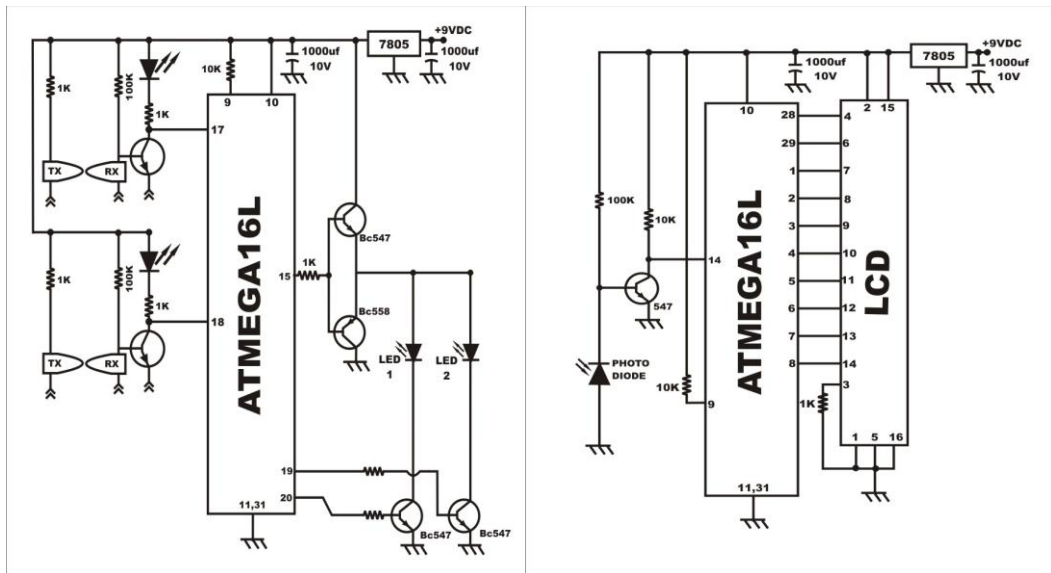

Fig: Schematic of Transmitter and receiver circuit used in proposed VLC based system.

The received signal from the photodiode gets amplified for detection at the microcontroller and then displayed at the LCD showing the appropriate route required for navigation. Values of resistances and capacitances are kept high to avoid damage to the electrical components keeping in mind the values mentioned in the data sheets. High Range capacitors such as 1000 mf installed to avoid damage to the electrical component as they act as storage units and store charge to avoid sudden increase or decrease in voltage levels. A Robotic vehicle is being used as a test mobile vehicle to install receiver circuit and when it comes under a street light connected with the above transmitter, the required route is displayed on the LCD with the help of visible light as medium of communication.

IR detectors are connected with photocell through microchips that are tuned to act on infrared light. IR here used as a Motion/ break-beam sensor to detect motion and work by having an emitter side that sends out a beam of human-invisible IR light. When a vehicle, installed with VLC receiver, passes through the LED street lights connected to the transmitter, it gives real time traffic information to the car driver and avoids traffic menace and conjunction.

V. Observation

After optimizing the circuit and its simulation, the hardware is developed and fabricated, thereafter installed in specifically designed robotic vehicle to simulate real time traffic scenario. The photodiode based receiver circuit is installed in robotic vehicle to facilitate decoding of VLC data and transmitter is being installed along with the street lights to simulate a conjunction between traffic light and VLC data which is needed to be transmitted.

After the real time implementation set up, up to 100 runs is being performed to analyse the system efficiency and accuracy towards the integrated VLC range. To facilitate traffic information prior to the driver before hitting traffic jam, the street light based wireless traffic situation data transmission makes some sense at this proposed system interlinking all existing amenities to construct a VLC communication system for traffic management.
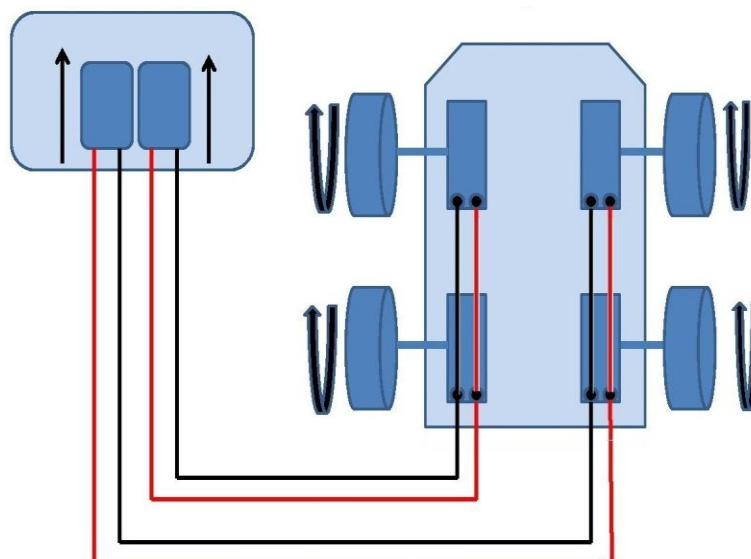
Fig: layout of robotic vehicle subjected to testing of VLC based traffic management system.

VI. Result & Discussion

After the realized simulation, the results have been generated and analyzed which compares the disturbances in the real time situation and artificially simulated situation. The proposed research and its implementation approach provide an alternative to the existing manual traffic management system that proves to be a failure many of the times.

Sending information from the street light is being done after conversion into bits through some coding scheme by a microcontroller and that gets transmitted with blinking LEDs. The transmitting system will be powered from a wall outlet whereas the receiving system will be powered by batteries and the computer / microcontroller combination. The fabricated PCB remains efficient even after hundreds of real time simulations which prove the capabilities of proposed system.

VII. Conclusion

The proposed paper produces a novel design in pursue of implementing VLC communication system in conjunction with wireless traffic management system and is definitely going to address the basic problem of traffic management. Apart from this, VLC can also be used as a communications medium for ubiquitous computing which have implications in various fields because light-producing devices such as indoor/outdoor lamps, TVs, traffic signs, commercial displays and car headlights/taillights are used everywhere. Using visible light is also economical for high-power applications and implications as human can perceive it and act to protect their eyes. Further implications include underwater optical/acoustic communication system, VLC based wireless optical communication, Blind indoor navigation system, etc.

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