LI-FI Based Vehicle to InfrastructureCommunication

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***Abstract*—This paper presents a novel method of wireless communication of Vehicle to Infrastructure (V2I) communication using visible light communication technology. It can provide audio safety information inside the vehicle through visible light communication. Traffic signals can be displayed in the LCD which is placed inside the vehicle. Also the traffic signals can be controlled according to the density of the vehicles in the junction. To take the density of the vehicle an IR pair sensor is placed at a certain distance from the traffic signal. The output of the sensor is given to the interrupt pin of the micro controller in the transmitter side. If the number of vehicles is greater, then density of vehicles is considered to be high. The widespread use of LEDs in traffic applications and the growing interest in intelligent transport systems (ITS) presents a number of opportunities for VLC applications. In short by using V2I communication real time transmission of traffic signal data to the vehicle is possible. This data can be used for collision detection and for enhancing driving safety.**

***Keywords*—Intelligent Transport System (ITS), Light Fidelity (LI-FI), Vehicle to Infrastructure Communication (V2I), Visible Light Communication (VLC).**

I. INTRODUCTION

With increasing demands for faster and more secure wireless communications, there is a pressing need for a new medium of wireless communication as the radio spectrum is already crowded [2]. Visible light is a medium that can address both of these needs. It is a relatively new technology with great potential. Visible Light Communications is essentially communication by means of optical light. Visible light communication (VLC) is a light emitting diode (LED) based optical wireless communication. The LED is suitable as an optical-signal-sending device because light intensity of the LED can be modulated at high speed in comparison with traditional lighting devices, such as incandescent bulbs and fluorescent lamps. Also LEDs are inexpensive, high energy efficiency and long operating life [4]-[6]. VLC uses LEDs to send data by flashing light at speeds that are undetectable to the human eye. The widespread use of LEDs in traffic applications and the growing interest in intelligent transport systems (ITS) presents a number of opportunities for VLC applications. Data transmission using LED traffic lights and LED brake lights is a typical application. The paper presents a novel approach for vehicle to infrastructure applications that can facilitates safe driving by adaptive traffic signal control, intersection movement assistance, and speed management and so on [1]. The fundamental analysis for visible light communication system using LED lightings [3] described that white LED offers advantageous properties such as high brightness, reliability, lower power consumption and long lifetime. Generally plural lights were installed in room. So their optical path difference must be considered. A further advantage was that visible light communication systems can transmit data more securely over short distances than other communication devices whose signals can be easily detected outside the rooms and buildings they originate in. This paper described about the influence of interference and reflection. Based on numerical analyses, the paper showed that the system was expected to be the indoor communication of the next generation. The proposed system presents a novel method of optical vehicle to infrastructure (V2I) communication using LED transmitter and a photo transistor as receiver. The infrastructure selected in this project is a traffic signal. In V2I the vehicle can communicate with the traffic signals through visible light and also density based traffic control system is incorporated in this project by using IR pair sensors. The traffic signals can be monitored within the vehicle and audio safety information according to the signal can be heard inside the vehicle. Since the communication is through visible light instead of radio wave it is very easy to implement. Thus vehicle to infrastructure visible light communication involves wireless exchange of critical safety and operational data between moving vehicle and roadway infrastructure [1]. Visible Light Communications is essentially communication by means of optical light. It falls under the category of free-space optical communications. Transmitting data via light is achieved by having the light source flicker on and off to represent a logic high and logic low signal respectively [13]-[15]. A receiver either photodiodes or a digital camera will detect the light coming from the transmitter and will interpret the signal. When the receiver detects light it is represented as logic high and when it detects no light at all from the transmitter it is represented as logic low. By turning the light on and off, the transmitter can transmit 0s and 1s. This is the simplest method that visual light can be used for digital communication [2]. Varying levels of light between on and off could allow for the transfer of more than one bit of information. The data rate of the transmission will depend on how fast the lights can turn on and off. LEDs are a popular choice for VLC communication as they can be switched on and off at a very high speed. Fluorescent lights used indoors can also be used as they flicker at a speed that is fast enough that the human eye cannot see [9]. The existing system is using traditional methods of communication over cables, wires and radio frequencies [3]. VLC is an alternative technology towards existing radio frequency RF based systems [2]-[9]. The IEEE has also developed a standard, known as the Wireless Access in Vehicular Environments (WAVE) to provide interoperable wireless networking services for transportation. The physical layer of WAVE is based on the IEEE 802.11p standard, which is an amendment to IEEE 802.11 and the upper layers are being standardized by the IEEE 1609 working group in the United States and by the International Organization for Standardization Technical Committee and the European Telecommunication Standardization Institute (ETSI) technical committee for ITSs

in Europe [2]. The vehicular communication using radio technology for improving automotive safety has various disadvantages. These small RF bands can quickly suffer from interferences when hundreds of vehicles located in the same vicinity try to communicate simultaneously. This in turn reduces the transmission power according to the congestion in the surrounding area. Vehicular dynamic spectrum access based on borrowing an unoccupied RF spectrum is also existed. Moreover RF band is restricted or banned due to the safety regulations such as industrial parks, oil, gas, mining industries, and military vehicle platoons. The radio frequency is emitted from various sources. The present civic life is full of electrical and electronic products like mobile phones, microwave oven, stabilizers, electric shavers, household remote controls, radars and transmission towers which emit invisible electromagnetic radiation. Radio frequencies are generating health issues to the developing nervous system and associated brain activities in children. The radio frequency had been observed to affect adversely the implanted pacemakers [10]-[11]. Infrared transmissions are inherently localized and governments do not regulate the infrared portion of the light spectrum. The standard is normally applicable for short-range and point-to-point communication and was used for providing wireless connectivity for devices that normally would use a cable-oriented solution. The another existing technology is bluetooth communication which is a high speed low-power microwave wireless link technology intended to exchange data over short distances from fixed and mobile devices, creating personal area networks. When Bluetooth enabled devices come within range of other such devices, they immediately exchange address information and create small ad-hoc networks which is known as piconet among each other. Bluetooth is a radio technology and had ability to penetrate solid objects and its capability for maximum mobility within the piconet [13]. VLC system is a solution for existing wireless communication systems. VLC has some interesting characteristics that are unique to optical communications systems. Light-based systems are confined by opaque walls and thus improve security and enhance reused of the channel in densely packed cells like adjacent rooms in an office. VLC can be added to an existing network without introducing new interference. Moreover, in cases when RF signals are perceived as a hazard, VLC can be applied as a practical alternative. Due to its directionality and containment properties, VLC is also a good candidate for near field communications. VLC is also a contender for providing indoor GPS. Light based positioning and localization is being explored by a variety of researchers as potentially more accurate and more easily deployed than RF or acoustic techniques [15]-[20]. The comparison between VLC and IEEE802.11p is shown in Table.1.

TABLE 1. Comparison between VLC and IEEE802.11p

TYPE	**VLC**	**IEEE802.11P**
Communication mode	Point to Point	Point to multi point
Latency	Very Low	Less than 50 ms
Data Rate	Up to 400Mb/s	Up to 54Mb/s
Range	Up to 100m	Up to 1 km
Frequency	400-790 THz	5.8 – 5.9 GHz
License	Unlicensed	Licensed
Cost	Low	High
Mobility	Medium	High
EMI	No	Yes
Power Consumption	Relatively Low	Medium
Coverage	Narrow	Wide
Weather Conditions	Sensitive	Robust
Ambient Light	Sensitive	Not Affected

II. PROPOSED SYSTEM

The paper presents a novel method of wireless communication of V2I communication using visible light communication technology. It can provide audio safety information inside the vehicle through visible light communication. Traffic signals can be displayed in the LCD which is placed inside the vehicle. Also the traffic signals can be controlled according to the density of the vehicles in the junction. To take the density of the vehicle an IR pair sensor is placed at a certain distance from the traffic signal. An IR sensor is basically a device which consists of a pair of an IR LED and a photodiode. The IR LED emits IR radiation and it is received by using a photodiode The output of the IR sensor is given to the interrupt pin of the micro controller in the transmitter side. If the number of vehicle become hundred then density of vehicles are considered to be high. Then green signal will turn on for a certain amount of time. The micro controller used in the transmitter section is Arduino Atmega 328. The transmitter collects various signals on the traffic light and converts to corresponding ASCII values. For each colour, transmitter sends a specific symbol. For instance the red colour is on, the transmitter will send '$' symbol to the receiver. The ASCII value corresponding to this symbol will serially send by the transmitter via its serial ports. The binarization of the value will be done by the analog to digital module in the transmitter section. Since the LEDs can switch in very high speed the transmitted data can't be interpreted by the intruder. This is one of the most attractive features of visible light communication that data can be transmitted more securely. The micro controller used in receiver section is PIC16F877A. It receives the transmitted bit serially. It performs display function like 'RED' for the traffic light red. Also converts binary form of data to analog form. The audio safety information signals are recorded in the various channels in APR module. This safety information can be played according to the data from traffic light through VLC. When a low to high transition of signal is detected in a specified channel it will get activate. By using this

proposed system, the audio safety warnings and information can be provided to each vehicle. Thus this system can prevent collision and can enhance the driving safety.

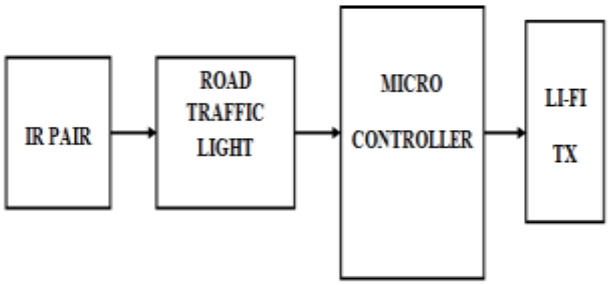

Fig.1 Block Diagram of Transmitter section

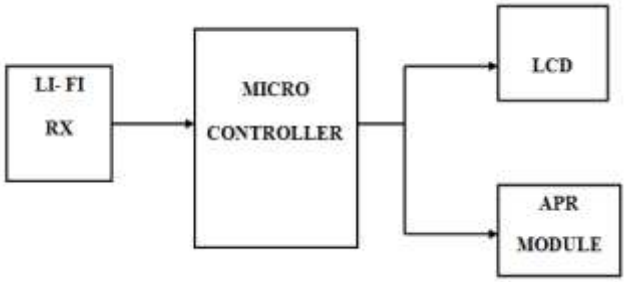

Fig.2 Block Diagram of Receiver section

III. HARDWARE DESCRIPTION

A. *Transmitter section*

Figure1 shows the block diagram of the transmitter section. The traffic light control according to the density and transmission of audio safety information to vehicle through LED traffic light using LI-FI transmitter is performed in this section.

1) LI-FI Transmitter: Li-Fi represents Light Fidelity. Li-Fi is the future upcoming technology and this can transmit the information through light at high speed as compared to the present wireless technologies. The Li-Fi technology can transfer the data through LEDs. It is a high speed and low cost wireless communication system, compared to Wi-Fi. It can provide high security, large bandwidth, and low cost. Different colour LEDs has different bandwidth and speed. The purpose of a transmitter is to send data to the receiver so that the other side can process and interpret the data. The purpose of the transistor in the transmitter analog system is to act as a switch controlled by the MCU. The transistor would connect an external power source to the LEDs instead of having the MCU to drive the LEDs directly. That way, more current or power would flow through the LEDs than what the MCU could output. This would result in brighter LEDs and achieving farther transmitting distance. The MCU would control the transistor and when the transistor receives a logic high, or 3.3V signal at the base, the transistor would turn on meaning it would allow current to go through from the external power source to the LEDs to ground. When it is off, no current will flow. The transistor BC548 is used as a switch and a current amplification device.

2) IR Pair: An IR pair sensor is an electronic device that emits infrared signals in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. In this paper IR pair is used to measure the density of vehicles in a junction. Based on the density, traffic signal can be controlled. The emitter is simply an IR LED and the detector is simply an IR photodiode which is sensitive to IR light of the same wavelength as that emitted by the IR LED. When IR light falls on the photodiode the resistances and these output voltages, change in proportion to the magnitude of the IR light received.

B. *Receiver section*

Figure 2 shows the block diagram of receiver section. The reception of optical data can be done by using a photodiode or a phototransistor. The received data is processed by a microcontroller in the receiver section and according to the data; audio safety information is played in the vehicle and traffic light condition is displayed inside the vehicle.

1) LI-FI Receiver: In receiver section a photo transistor is used. A Phototransistor is an electronic switching and current amplification component which relies on exposure to light to operate. When light falls on the junction, reverse current flows which is proportional to the luminance. Phototransistors are used extensively to detect light pulses and convert them into digital electrical signals. These are operated by light rather than electric current. Providing large amount of gain, low cost and these phototransistors might be used in numerous applications. Phototransistors are transistors with the base terminal exposed. Instead of sending current into the base, the photons from striking light activate the transistor. This is because a phototransistor is made of a bipolar semiconductor and focuses the energy that is passed through it. The photo transistors are activated by light particles and are used in virtually all electronic devices that depend on light in some way. All silicon photo sensors (phototransistors) respond to the entire visible radiation range as well as to infrared. In this paper a photo transistor along with a comparator can be used. If the light illumination varies photo transistor current also changes. Here when light is not present then the resistance of transistor will be high, which makes output of comparator low. When light is present then the resistance will be very less so output of comparator is high. The base of the photo transistor would only be used to bias the transistor so that additional collector current was flowing and this would mask any current flowing as a result of the photo-action. The collector of an n-p-n transistor is made positive with respect to the emitter or negative for a p-n-p transistor. The light enters the base region of the phototransistor where it causes hole-electron pairs to be generated. This mainly occurs in the reverse biased base-collector junction. The hole-electron pairs move under the influence of the electric field and provide the base current, causing electrons to be injected into the emitter.

2) APR Module: APR9600 is a low-cost high performance sound record/replay IC incorporating flash analogue storage technique. Recorded sound is retained even after power supply is removed from the module. The replayed sound exhibits high quality with a low noise level. Sampling rate for a 60 second recording period is 4.2 kHz that gives a sound record/replay bandwidth of 20Hz to 2.1 kHz. However, by changing an

oscillation resistor, a sampling rate as high as 8.0 kHz can be achieved. This shortens the total length of sound recording to 32 seconds. Total sound recording time can be varied from 32 seconds to 60 seconds by changing the value of a single resistor. The IC can operate in one of two modes: serial mode and parallel mode.

C. Microcontroller

This paper uses Atmega 328 in the transmitter side and PIC 16F877A in the receiver side. Arduino is an open-source physical computing platform based on a simple input output board and a development environment that implements the Processing language. The ATmega328 is a single chip micro controller created by Atmel in the mega AVR family. PIC 16F877 is one of the most advance microcontroller from microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality and ease of availability. Using Arduino IDE the characters send for each light by the transmitter can be seen using serial monitor.

IV. Evaluation of Tools

A. Embedded C

It is a set of language extensions for the C Programming language by the C Standards committee to address commonality issues that exist between C extensions for different embedded system. Embedded C uses most of the syntax and semantics of standard C, e.g. main function, variable definition, data type declaration, conditional statements (if, switch, case), loops (while, for), functions, arrays and strings, structures and union, bit operations, macros, etc. For programming we use MikroC PRO for PIC software. Programming IDE for PIC is shown in figure 3.

Fig. 3 Programming IDE of PIC

B. Arduino IDE

The Arduino programming environment is easy to use for beginners, flexible enough for advanced users to take advantage of as well. For researchers, it is conveniently based on the processing programming environment. Arduino boards are relatively inexpensive compared to other microcontroller platforms. The Arduino software runs on Windows, Macintosh OSX, and Linux operating systems. Most microcontroller systems are limited to Windows. Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. The Arduino IDE is shown in figure 4.

Fig. 4 Programming IDE of Arduino

V. Results and Discussion

Hardware output is implemented using micro controller Arduino Atmega328 in the transmitter section and PIC16F877A microcontroller in the receiver section. LEDs can be used to transfer the data from the traffic light to receiver section. A photo transistor is used to receive the data send by LEDs. The APR9600 voice module is used to provide audio safety information like go, stop and wait for the signals green, red and yellow respectively. Density of the vehicles can be measured using IR pair and according to the density traffic light can be control in each junction. Since the proposed system using low cost, low power, high efficiency LEDs the overall cost of the system implementation can be reduced. Software simulation can be done using Proteus 8 software. It contains a debug environment for the program code of the microcontroller. For the simulation .hex file and .COF the

compiled software are required. Hardware output is shown in figure 5.

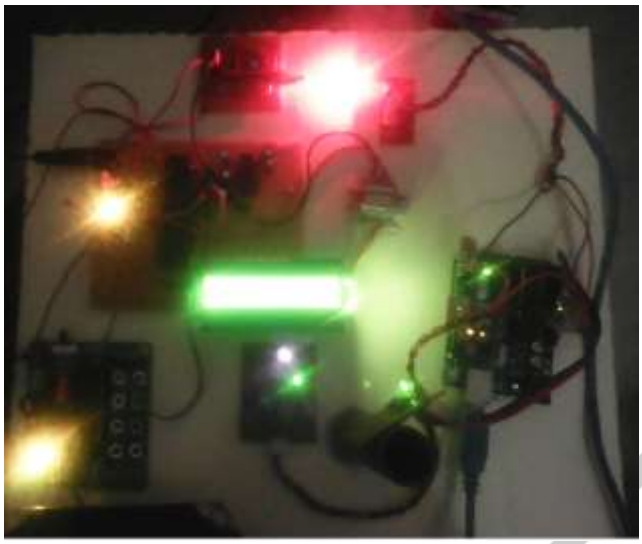

Fig.5 Hardware Output

VII. Conclusion and Future Scope

This paper presents a novel method for enhancing automotive safety using vehicle to infrastructure communication (V2I). Visible light technology is key element used for wireless transmission of data. In V2I the infrastructure used to communicate is the traffic light. Traffic light which can be controlled according to the density of vehicles in the junction is also incorporated along with this VLC technology. IR pair sensor is used to measure the density of vehicle. The widespread use of LEDs in traffic applications and the growing interest in intelligent transport systems (ITS) presents a number of opportunities for VLC applications. In short by using V2I communication real time transmission of traffic signal data to the vehicle is possible. This data can be used for collision detection and for enhancing driving safety. During practical implementation in roadsides, it is possible to apply modulation techniques for effective communication. The system can use On-off keying (OOK), Pulse position modulation (PPM) and Pulse amplitude modulation (PAM), but more resilient technique is Orthogonal Frequency division multiplexing (OFDM). Visible light communication is an emerging technology in wireless communication field. VLC can be incorporated in automotive applications to enhance the driving safety is one of the major acceptance of optical V2I communication. VLC provides an additional feature if the receiver incorporates an image sensor or a camera. Specifically by using image or video processing to detect and recognize moving vehicles, safety applications can be integrated in future. For example the system can find applications in methods of enhancing driving safety, adaptive cruise control, collision warning, pedestrian detection, and providing range estimations for nearby vehicles.

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