International Journal of Research in Advent Technology, Special Issue, August 2018
E-ISSN: 2321-9637
International Conference on "Topical Transcends in Science, Technology and Management" (ICTTSTM-2018)
Available online at www.ijrat.org

Smart Vehicular Communication System Using Li Fi Technology

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ABSTRACT

This paper develops a smart vehicular communication system using LiFi technology which provides protection against vehicular collisions on the roads. Li Fi (Light Fidelity) is an emerging technology which uses the visible light spectrum for communication. This project focuses on the safety on roads in which the headlights, which consists of LEOs acting as transmitter communicate with photo sensors acting as receiver. White LEOs used in the head and tail lights can effectively be used for short range communication with the photodetectors. The application is cost effective as LEDS are cheap and simple algorithms are proposed for signal generation and transmission. The basic transceiver circuits are implemented and the results are given. Simulations of the experiment are done using Proteus 8 Professional.

KEYWOROS-Li Fi technology, VLC, Trans-impedance amplification, OFDM

1. INTRODUCTION

A. Lifi technology

Li-Fi is a wireless technology which uses the band of visiblelight for transmission which is 10,000 times more than theband used in WiFi communication. It is fast, useful in secure communications as light cannot penetrate the walls and cheap as LED lights are used for data transmission. The data is transferred by encoding it in the LEDs in digital form. The flickering of the LEDs give the output as 0 or l. Persistence of vision makes the flickering undetectable for the human eye. Different strings of O's and 1's can be decoded to give the transmitted information. The block diagram In Figure I depicts the working of a Li Fi system.

The LEDs act as light source, that is, 'transmitter', which transmits O's or l's. A silicon photo diode acts as a receiving element, that is, 'receiver'. By proper amplification, modulation and signal processing, data can be received by devices like mobile phones, LCDs, laptops, etc.

The applications are numerous and if put in practical use, every bulb can soon be used as a Wi-Fi hotspot thus creating a cleaner, greener, and safer future [8]. It is an application of VLC which uses visible light between the wavelength 780 nm and 375 nm. For indoor applications, white Light Emitting Diode (LED) is a promising technology for short range, high speed wireless data transmission for which inexpensive transmitter and receiver circuits can be designed and transmission up to a range of 0.45m can be achieved. However for outdoor applications, it becomes difficult to control the environmental conditions so certain novel modulation techniques like OFDM could be employed which improves the range of transmission. Based on this,work is done in which DSSS modulation technique is used forVLC circuits to achieve data transmission range up to 40m[2]. Moreover, the frequency spectrum due to the current wireless technology is crowded which gives motivationtowards working for the possible applications of visible lightcommunication [1]

B. Vehicular communication

The best way to prevent head-on collisions between vehicleson the roads can be done by communication amongst them. Also inter-vehicle communication is one of the most effective applications to ensure safety from vehicular accidents. It is100 times faster and cost effective than the wireless communication using [R spectrum. Quantification of using Li fi over Wifi in vehicular communications is typically becausethe cost of the components is less as LEDs have turned up to be commonly used in automotive lighting [4]. VLC transceivers have been implemented using edge emitted laser diode and silicon photo diode for bi directional high speed and short range communication. The implemented design operates in a full duplex mode at 120Mbits/s [5]. Transceivers have also been designed for vehicular visible light communication which was tested using a modified version of the 802.11 MAC protocol [6]. Another implementation includes designing a transmitter and receiver where the transmitter includes a led driver to make to current constant so as to protect the led, and the receiver module consists of a trans-impedance amplifier toget a clear output [7]. We found that it is necessary to make the technology using the equipment already present in the vehicles such that minimal additional components need to be added in order to make the technology working.

2. PROPOSED DESIGN

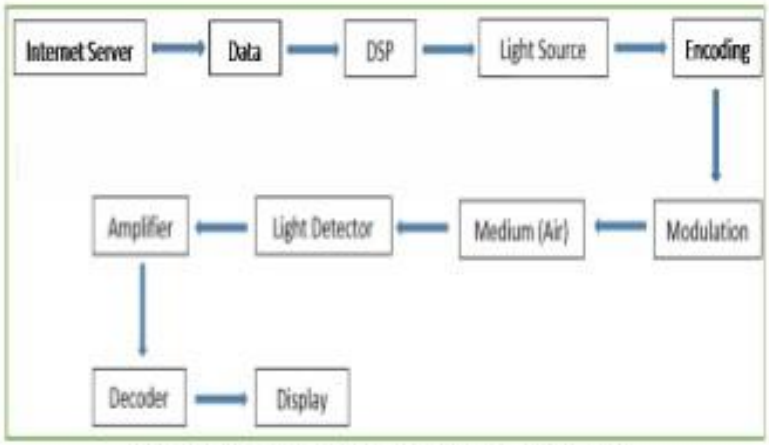

Figure 1: Implementation block diagram.

The existing equipment used in the cars can beharnessed to make the design cost effective. The head lamps used in the cars are mostly high powered white LEDs. The speedometer reading is converted to the digital form using amicroprocessor which is given as input to LEDs. The LEDsproduce the digital sequence which travels in a wireless channel to the photodiode. The current generated by the silicon photo diode is decoded to a digital sequence using ADC and the number represented by the sequence carries the information which is used to alert the driver in the vehicle following the one which transmits its speed. Our paper is focused on the effective design of using the existing technology in cars rather than adding new circuits and making the implementation complex.

Since minimal cost is added the design is cost efficient. Since data is encoded for a particular car to a particular car it decreases the probability of error in thetransmission which can occur due to intervention. The algorithm includes classifying the speed into low, medium andhigh speeds, rather than comparing the present speed from the previous one or measuring the distance by using the transit time.

A. During daylight

The head and tail lights of the cars are normally off.When the lights are switched off, the off time of led will be greater than its on time, so the headlights would appear to be off at all times transmitting data say 00000100001 to the receiver in other cars giving information about its speed and toalert if the speed suddenly changes. The transition can be in the form if the medium speed transmits data 001100110011, then slow speed would transmit 000010000100001 and this sudden change in bit stream would alert the car behind to reduce its speed.

B. During night

The head and tail lights are normally on. The ontime of a led will be greater than the off time so while flickering, the led will appear to be on at all times, however it would be transmitting a bit

stream of data say I III 1011111 to the receiver in the other cars giving information about its speed. For example, if the medium speed transmits 1110 lllOlllO, then slow speed could transmit 11110 llll 0 and accordingly alert signal would be sent.
The data stream to be transmitted is controlled by a microcontroller which uses PWM signal to control the off and on time of led. The data transmitted is decoded at the receiver side and relevant instructions and alert signals are displayed.

3. IMPLEMENTATION

The block diagrams in Figure 2 and 3 describes the algorithm used in this technologyOn the transmitter side, analog speed from the speedometer is fed to the microprocessor which classifies the speed in terms of low, medium or high. The data is converted into digital form using ADC and PWM is generated which drives the LED acting as the transmitter. The most efficient and cost effective light that can be used in cars is a white LED. Each LED requires 3.6V DC voltage and uses 30 milliamps of current and has a power dissipation of 100 m Watts.. However it may vary depending upon the LED material. Also due to the directional nature of LEDs, the need for reflectors and diffusers is reduced delivering light in an efficient manner to a specified direction.

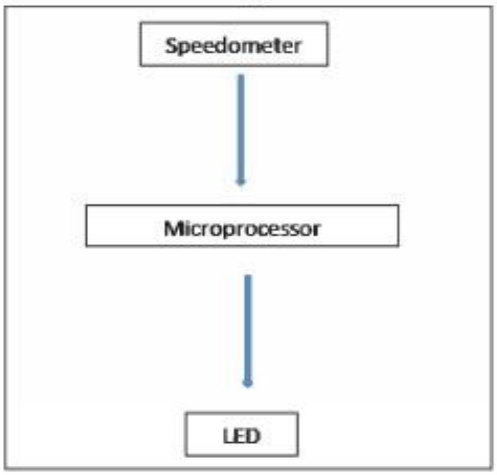

Figure 2: Transmitter Block diagram

The optical power generated internally by an LED is given by the equation

$$P_{int} = R_r\, h\nu = \eta_{int} \frac{i}{e} h\nu$$

Where Rr is equivalent to number of photons generated per second
$h\nu$is the energy of each photon $n_{int}$is the internal efficiency i is the input current
$e$is the elementary charge on an electron

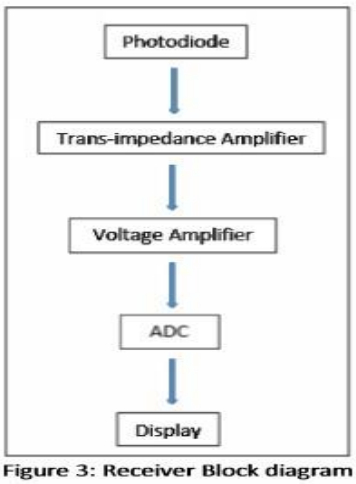

Figure 3: Receiver Block diagram

The generated power varies depending on the semiconductor material used for fabrication which depends linearly on the input current as shown in Figure 4.

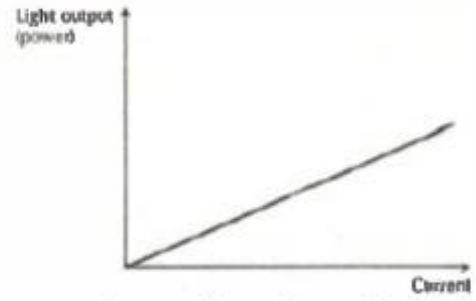

Figure4: Led Output characteristics

The basic transmitter circuit is given in Figure 5.

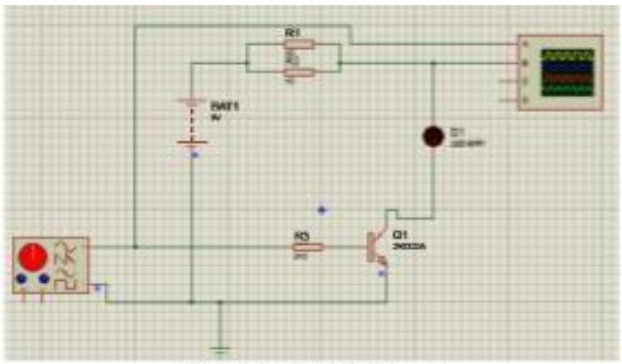

Figure 5: Transmitter circuit

The function generator provides the PWM signal which drives the LED. Transistor 2N2222A acts as a small signal switch.

On the receiver side, photodiode detects the photons and generates current in the external circuit which is proportional to the incident power. The basic receiver circuit is shown in Figure 6.

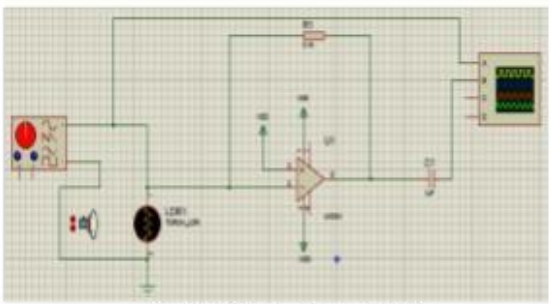

Figure 6: Receiver circuit

A photo diode is a semiconductor device that converts light into current. The current is generated when photons are absorbed in the photodiode. A small amount of current is also produced when no light is present. The time of response of a silicon photo diode is a measure of its sensitivity to light and is defmed as the ratio of photo current I_P and incident light power at a given wavelength.

$$R_\lambda = \frac{I_P}{P}$$

The responsivity varies with the wavelength of incident light as shown in Figure 7.

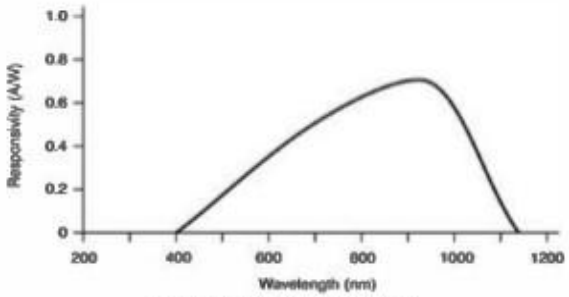

Figure 7: Photodiode Response

By creating an array of photo diode in parallel the current generated can be increased. A trans-impedance amplifier which converts the generated current into voltage is used.

The signal received through photo detector is very weak and it is in the mV range, so it needs to be amplified. Hence voltage amplifier circuit is designed to amplify the detected voltage. The LM324 is a low-cost, quad operational amplifiers. It has several distinct advantages over standard operational amplifier types in single supply applications. They operate at supply voltages in the range of 3.0 V to 32 V with quiescent currents. An ADC is used to convert the analog voltage into digital output which consists of transmitter in bit stream. Thus the transmitted signal is recovered back at the receiver side.

4. RESULTS AND OBSERVATIONS

Figure 8 shows the output of the transmitter circuit. The blinking of the LED is controlled by the signal generator, which send a bit stream, e.g. 1010101010 and then changes the stream as 11110000 llll 0000 based on the change in the speed of the vehicle.

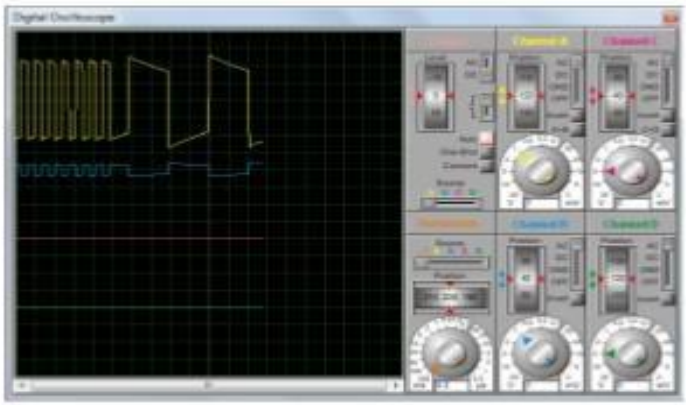

Figure 8: Transmitter output

Similarly, Figure 9 shows the output of the receiver side where the LDR detects the bit stream transmitted by the LED light, produces a current and changes it into voltage and gives the amplified output

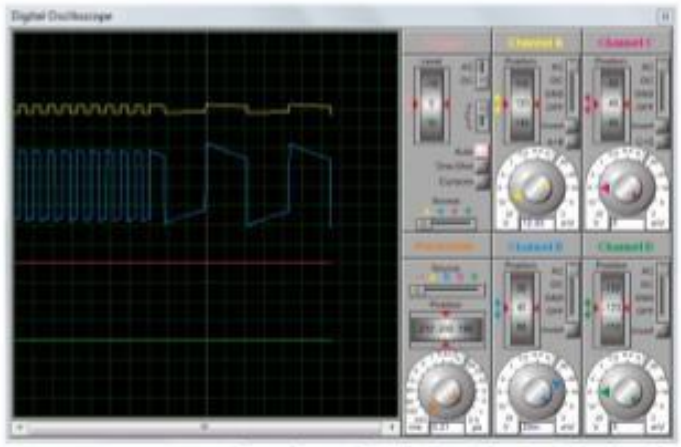

Figure 9: Receiver output

Further, the output of the receiver circuit can be fed into the microprocessor which changes into digital form and thus the transmitted data can be recovered back at the receiver side.

5. CONCLUSION

Simulations show that the LEDs transmit the data inform of digital sequence and photo diode receives the digital sequence without error. Thus we conclude that the proposed design can be implemented in the cars to avoid collisions. The cars alerting the driver can make the roads safer and reduce the risk of loss of lives. The design is cost effective. However in real time there can be disruptions in the transmission due tonoise and attenuation in which can be tackled by using novel modulation techniques which adds on to the cost of the technology making it functional and effectual. A complete prototype of the system will be implemented and tested to check the effectiveness of the circuits in real time and to achieve the longest possible range for the application.

Taking into account the vast potential of Li-fi technology it can be effectively used in applications like disaster management in the case of earthquake and floods, cheaper internet in air crafts, biomedical and underwater applications [3]. In the case where wireless communication is affected due to environmental conditions Li-fi can act as a reliable source to communicate thus proving to be a viable technology.

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