Indian Journal of Science and Technology, Vol 9(11), DOI: 10.17485/ijst/2016/v9i11/85090, March 2016
ISSN (Print) : 0974-6846
ISSN (Online) : 0974-5645

Li-Fi Technology based Fleet Vanguardand Security

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Abstract

Objectives: This paper ensures to enhance the quality of Intelligent Transportation System by combining the technologies of GPS and Li-Fi to provide an effective vehicle communication and protection between the fleet of vehicles. Using Li-Fi the data stream is transmitted in form of bits through visible light. **Methods:**A low power microcontroller TI MSP430F5529 is interfaced with Li-Fi module through which data such as speed and direction of vehicle is transferred between the leading and following vehicle. In case of vehicle goes out of range, the location of the vehicle is informed using GPS and GSM technology to the leading vehicle and the base station. This Li-Fi communication happens between the vehicles at high speed while the urgent messages can be transferred through the GSM module which overcomes the RF band limitation. **Findings:** In our prototype the usage of LEDs yields high speed data transmission, improves energy savings and requires less maintenance and also the Li-Fi technology is safer as it eliminates the harmful radiation intrusion. High directional communication ensures good message integration with ideal reachability and reduced latency.**Applications:**As the designed module combines the illumination, communication and tracking purposes together, the operating costs of the vehicles is highly reduced. Our prototype will provide a reliable and an eco-friendly solution which enables people to enjoy high end technology at an economical rate.

Keywords: Fleet, LED, Li-Fi, Phototransistor, Vehicle Communication, Visible Light

1. Introduction

Nowadays of fast growing environment, Visible Light Technology has taken its own place in the data communication field. One special characteristic of LED is to light on and off very fast[1]. The data can be transmitted by lighting LED on and off ultra-high speed. By using the visible light for the data transmission, many problems related to radio and IR communications are solved. The visible light communication has characteristics to be ubiquitous, very high speed, reliable and low cost[2].It is a form of green technology as it is harmless for people and electronic devices, compared to that of radio and infrared communications.Vehicular communications play a significant role in Intelligent Transportation System (ITS) and communications area.In typical VANET scenario, through inter-cluster communication a reliable communication can be established[3]. Thus solving the increasing difficulties in road transportation and information reliability and connectivity. Nowadays, there is a growing interest on the use of Led or Solid-State lamps not only as illumination because of its energy efficiency and robustness but as a source for optical wireless transmission, especially in the V2V technology. The impact in the performance of system can be improved by changing the technology[4]. Due to the efficiency of LEDs, it can be widely used forboth as lighting and communication purposes in the automotive fields which naturally improves the system performance.

Some related works were surveyed to understand the technique implementation. Authors proposed a design

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to implement Li-Fi technology in vehicle communication for two scenarios[5]. In first scenario to avoid collision, the application of brake in one vehicle is indicated to the vehicle behind it by signaling slow down message transmitted through light streams. In the second scenario the speed of the vehicle when moving near the T-junction is informed to other vehicle by using LED at headlights. To implement this paper every vehicle needs to be equipped with the Li-Fi facility which is laborious.Authors has demonstrated a design implementing V2V using VLC technology which used LED as transmitter and a camera with OCI as receiver[6]. The Leading Vehicle collects its own various internal data (such as speed) and sends these data to the Following Vehicle by optical signals. The received information can be used for vehicle control and to avoid collisions. The system is little expensive as many camera parts cannot be shared.Light Fidelitymeans the wireless data transfer using LED[7]. The main concept behind the Li Fi is "Data through Illumination". It transmits data with the help of an LED bulb having variation in its intensity which has a speed of actually faster than which human eye can follow. To convert data to be transmitted in the form of light waves they used a processor MSP430G2553. This may solve issues such as the shortage of radio-frequency bandwidth and also allow internet where traditional radio based wireless isn't allowed such as aircraft or hospitals.

In reference to the above designs and other papers referred, on integrating the merits we aim to propose a design to enhance the vehicle to vehicle communication in the field of fleet management using the Li-Fi technology.The RF bandwidth limitations can be solved by the advent of Li-Fi technology.In the proposed project, Visible Light Communication (VLC) is the data communication technology along with GPS and GSM technologies are used. The project introduces Li-Fi technology using low power microcontroller TI MSP430F5529 to offer a vehicle protection and V2V communication, between the leading vehicle and the following vehicle where data stream is transmitted in form bits through visible light. In case of if one vehicle goes missing, the GPS is activated to find the location and via GSM the data is transmitted to the leading and to the base station.This Li-Fi module can be used for communication between the vehicles at high speed while the urgent messages can be transferred through the GSM module which overcomes the RF band limitations.

2. System Design

In the proposed system, TI LP MSP4305529 microcontroller is used which features a powerful 16-bit RISC processor and 16-bit registers contribute to maximum code efficiency. The architecture is optimized by extensive low-power modes, to achieve extended battery life in portable measurement applications. LED is used as transmitter which has a characteristic to light on and off very fast. The data can be transmitted by using light streams, the distance that light could cover depends on the light intensity the LED used. The system uses GPS module for location tracking in case if the vehicle goes out of coverage range. SIM28M is a stand-alone or A-GPS receiver. SIM28M can track as low as 165dBm signal even without network assistance. GSM SIM800 is used to provide alert message to the leading vanguard vehicle and to the base station about the following vehicle which went off-the-track. SIM800H support Quad-band 850 to 1900MHz GSM/GPRS in a LGA type which can be embedded in the customer applications. It can transmit audio and text information with low power consumption.

2.1 Block Diagram

2.1.1 A Leading Vanguard Vehicle Li-Fi Module

The block diagram Figure 1 shows the leading vehicle Li-Fi module placed in theleading vehicle.

This module acts as both illuminating device andcommunicating device by means of Li-Fi technology The MSP430F5529 microcontroller controls the over-

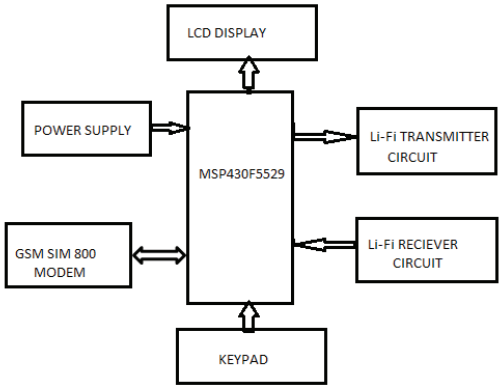

Figure 1. Block Diagram of Leading Vanguard vehicle Li-Fi module.

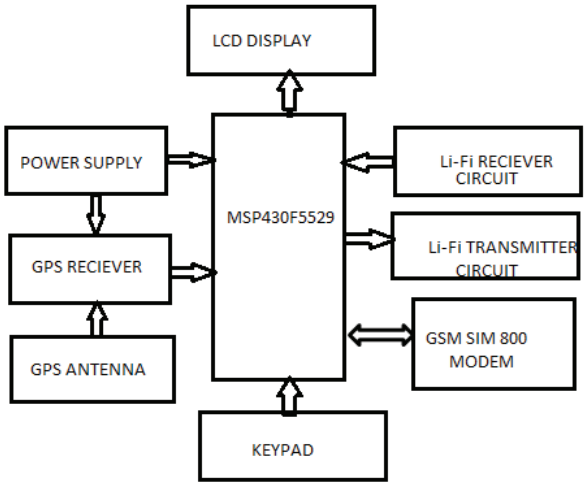

Figure 2. Block diagram of following vehicle Li-Fi module.

all module operation. Li-Fi module consist of a LED and Phototransistor. LED which acts as a transmitter that passes the information through light streams to the vehicle following the master vehicle. Phototransistor is used to collect the light streams transmitted from the vehicle following. Keypad is used to input data that the user wants to inform other vehicle. LCD displays the processed information. The GSM SIM800 module is used to receive the alert messages sent from the following vehicle and it forwards itto the base station.

2.1.2 Following Vehicle Li-Fi Module

The Figure 2 represents the block diagram of the following vehicle Li-Fi module placed in the following.

The construction is very similar to the Leading Vehicle Li-Fi module in addition the following vehicle is equipped with the GPS module to track its location. When the following vehicle loses the communication link with the leading vehicle. Immediately the GPS receiver module which collects the latitude and longitude information starts to track the vehicle using GPS antenna. The GSM SIM 800 is used to transmit the alert message to the leading vehicle.

3. Software of the Proposed System

3.1 Energia

Energia is an open-source platform for electronic prototyping. Energia includes an integrated development environment (IDE) that is based on Processing. The low-cost microcontroller LaunchPad board is made by Texas Instruments. The latest release of Energia supports the majority of the LaunchPad product offerings.

3.2 The Pseudo Code for Li-Fi based Fleet Vanguard and Security

Start the Program
Initialize the header files, macros, variables.
Initialize Li-Fi modules, GPS and GSM modules.
Set the phone number and update the initial location.
Send the speed and direction data through Li-Fi commu
    nication.
Check for acknowledgement
    If acknowledgement received
    Continue the Li-Fi communication
    Else
    Wait for 5 count
                If acknowledgement received
                Continue normal Li-Fi operation
                Else
                Activate the GPS, get the location and
                    forward the message through GSM.
End the program

4. Experimental Results

This Li-Fi range depends on the light intensity of the used light emittingdiode. This range of the illumination distance is used as range detector. If the vehicle following goes out of range,then there occurs communication failure because data is transmitted through light streams which can travel only certain distance. Then the vehicle keeps waiting for reply information from the receiver vehicle for about five counts. If the reply does not arrive within a certain period of time an alert is sent that vehicle is missing to the leading vehicle. Then the GPS tracker is switched on and the location is tracked and informed through GSM SIM 800 to the vanguard vehicle and then the information is communicated to the base station. The Figures 3 and 4 represents the Li-Fi module of leading vehicle and following vehicle respectively.

By taking the prototype to product side, an array of LEDs can be used. On the receiver side an array of phototransistors for receiving the transmitted data. Line-of-sight is an important criterion which also has to be considered while taking it to a product. With GPS and

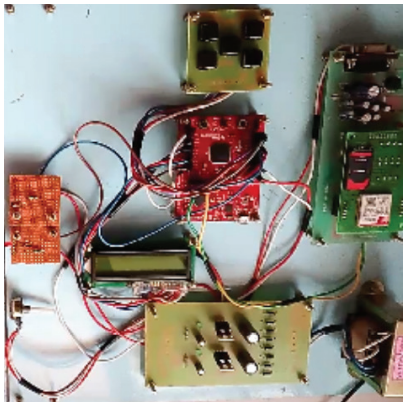

Figure 3. Li-Fi module of the Leading vehicle.

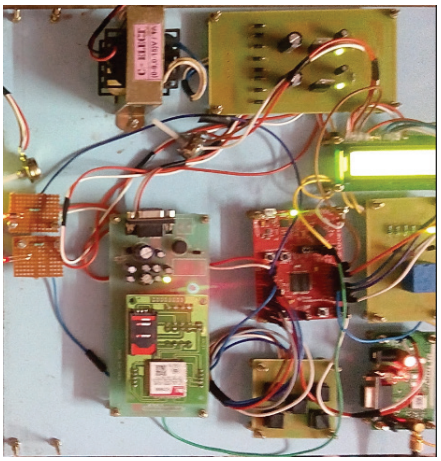

Figure 4. Li-Fi module of the Following vehicle.

GSM SIM 800 on board, a resource efficient communication and tracking device is obtained.

4.1 System Initialization

The GSM module is initialized and the necessary setup required for text transfer is made. The GPS antenna checks for the signal strength. Now the module is ready for both the illumination and communication purpose. Once the necessary initial setup is made, both the module requests for the phone number to which it should send message is to be entered.The Figure 5 represents process of the system initialization and obtaining phone number .

4.2 Speed and Direction Adjustments

The vehicles can send speed adjustments and direction guidance to each other. Three directions are informed

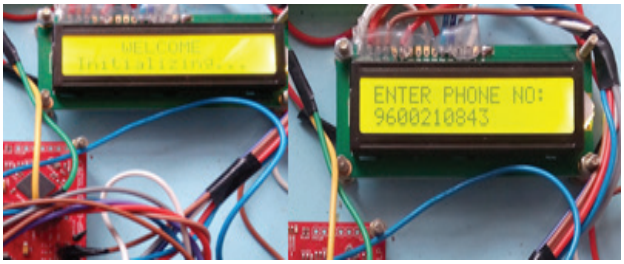

Figure 5. System initialization and Obtaining phone number.

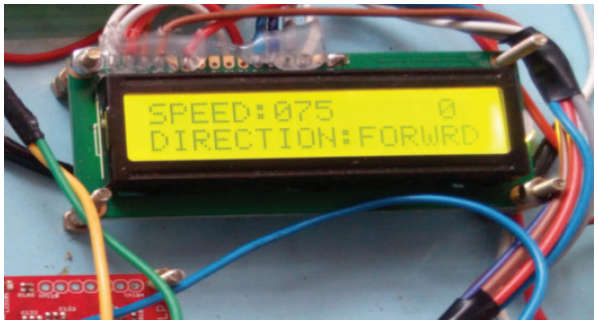

Figure 6. Received speed adjustment information.

namely Straight, Left and Right. The change in the speed and direction are displayed on the LCD screen. Figure 6 represents the speed adjustment information sent from the other vehicle is displayed on the LCD screen.

4.3 Obtaining the Location Information

In case the vehicle goes missing, primarily the Li-Fi system placed in both the vehicle modules waits for few time period and if the acknowledgement has not received within certain count, the GPS and GSM is activated and immediately the longitude and latitude location of the missing vehicle is texted to the vanguard vehicle and it is displayed in the LCD. Figure 7 represents the process of obtaining the location information

4.4 Alert Message

Once the location information is obtained through the GPS receiver powered by GPS 001 the alert message is sent to the vanguard vehicle and base station using the GSM SIM 800 module placed in the vehicles. Figure 8 shows the alert message sent by the leading vehicle about following vehicle which went off the track to the Base station.

Figure 7. Obtaining the location information.

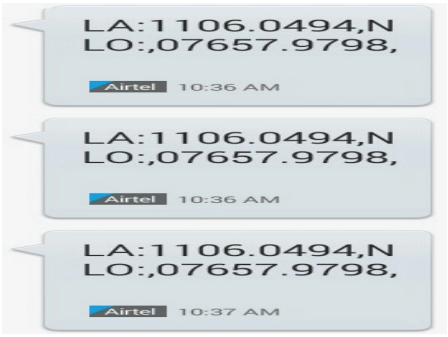

Figure 8. Message received in the base station.

5. Conclusion and Future Work

The concept of Li-Fi had been combined along with vehicle to vehicle communications can significantly improve the energy efficiency and as well as subdue the management costs. The dual purpose communication and LED lighting can be a solution to RF bandwidth limitations[8]. We propose an operative solution by envisioning lights transmitting messages between the fleet vehicles. Guiding information and messages can be transmitted via light pulses by periodic 'on and off' of the LED. If the following vehicle goesout of range, then by using GPS and GSM the missing vehicle is tracked and informed to the control station. The front and rear light in vehicles can send data to enable genuine interactive vehicularcommunications enabling users on the move to enjoy full network communications. As a result, the proposed system satisfies both resource conservation and efficient data transmission. In the near future the system can be enhanced to transmit data at afaster rate to enable users to communicate anytime and anywhere authentically faster and eco-friendly way.

6. Acknowledgement

The first author thanks Dr. S. Jayanthy for supporting and encouraging this research work and also the peer review committee members.

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