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Vehicle Communication System Using Li-Fi Technology

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Abstract— ***In this paper, presents the designs of a small-scale prototype of a vehicle to vehicle communication system using light fidelity (Li-Fi) technology. The new technology that was developed in the last few years, which still needs more investigations on its sustainability for outdoor vehicular networks. The vehicle to vehicle communication is the most effective solution that has been used in order to reduce vehicles' accidents. The proposed use of Li-Fi technology comprises mainly light-emitting diode (LED) bulbs as means of connectivity by sending data through light spectrum as an optical wireless medium for signal propagation. In fact, the usage of LED eliminates the need of complex wireless networks and protocols. In this work, several case studies are, presents to mimicking the vehicle to vehicle communication. The numerical simulations are done by using proteous package and the experimental results are also presented. The proposed system gives better results in both simulation and hardware***

Keywords—Light Emitting Diode, Vehicle to Vehicle Communication, Visible Light Communication, Sensor, and LCD Display.

I. INTRODUCTION

The oman is one of the most countries in the world that has an alarming record in number of deaths/disabilities due to the tremendous number of accidents. In fact, such statistics have made the public and academia in Oman to the tremendous number of accidents. In fact, such statistics have made the public and academia in Oman to propose and initiate cost effective solutions in order to mitigate the consequences of accidents [1]-[3]. Vehicle to vehicle communications, for instance, is one of the previous trends, which is one of the most effective Mechanisms that are implemented in automobiles to provide safety and a protocol of communication [4].

(A) 5.9 GHz DSRC Wireless

Dictated short range (1000 meters) communication (DSRC) for Intelligent Transportation Systems (ITS) has opened the door to hundreds of projects and applications of vehicle to vehicle communication around the world. In 1999 the US federal communication commission reserved licensed

bandwidth of 75 MHz spectrum around 5.9 GHz that allows information to be exchanged among vehicles regardless of their brand [5]. This spectrum will provide very high data rates with low latency and high security in matter of supporting this wireless communication between vehicles, set of wireless link for V2V communications and IEEE P1609.x/D5.8 protocols for information exchange across the wireless link.

(B) Wireless Ad Hoc Networks

Vehicular Ad-hoc network (VANET) technology was introduced in 2000 as a specified application of mobile ad hoc networks (MANETs). This network uses vehicles in the road as a router or node in order to communicate at a distance of 100-300 m using several protocols. The networks basically rely on Wi-Fi, WI-Max and DSRC technologies in addition to 3G networks [5], [6].

(C) Without Wi-Fi or GPS

It have proposed vehicle to vehicle communication system that does not require a tracking global

positioning System or even a Wi-Fi or 3G wireless connectivity. It was proposed to use Programmable Interface Controller (PIC) sonar which sends 40 KHz short pulse of sound that is undetectable by human ear. The echo of the signal will be detected by microcontroller. The distance is calculated by the time required for echo signal to be transmitted and received. This technology is demonstrated in the figure below. Several research works have been in literature for vehicle to vehicle communication Attempted using an advantage of light. As light frequency spectrum is huge, it is beneficial to be adopted in a short-range wireless communication. In this work, we aim to develop a cost effective yet inexpensive mechanism for vehicle to vehicle communication through the use of an optical wireless communication medium, which is light. The Figure 1 shows the communication between vehicles using sonar pulse.

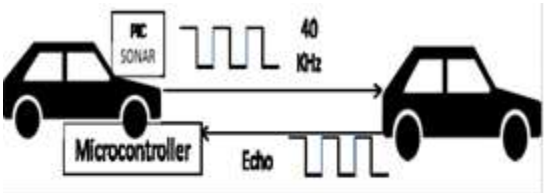


Figure 1: communication between vehicles using sonar pulse

II. SYSTEM DESIGN

The proposed system requires a transmitter and a receiver in each vehicle in both rear and front sides of the vehicle. Standards were needed to ensure that vehicles understand each other, for example, IEEE 802.11p-2010 standard [7].

A. Software

AVR OSP 2

The Atmel AVR Open Source Programmer (AVROSP) is an AVR programmer application equivalent to the AVR Program tool included in the AVR Studio. It is a command-line tool, using the same syntax as the other command-line tools in the AVR Studio. The open source code and its modular design make it easy to port the application to other platforms and to add support for other programmer types and communication channels. Currently, AVROSP supports the programmers described in the Atmel AVR109 and AVR910 application notes, through the standard PC serial port. The application note describes how to add more support. AVROSP reads and writes Intel HEX files and can use Most of the top-level work is encapsulated in the Job Info class. It uses objects of class XML File, HEX File and AVR Device to read and write XML and HEX files and to extract device information from the Part Description Files. The two helper classes Utility and Error Message are used throughout the application. The part of Job Info that communicates with the programmer does not need to know what kind of communication channel to use. It decodes the command line and creates an instance of the required derived class, e.g. the Serial Port class. The rest of the code just works through the generalized Communication Channel parent class. Currently, only a class for the PC COM port is implemented, but to use e.g. USB or TCP/IP communication, you could derive a specialized class from the Communication Channel base class, and add a check for this channel type in the command line. The same method is used for the programmer type. The code that operates on the programmer does not need to know which type of programmer is attached. The Job Info class retrieves the programmer ID string and creates an appropriate object for the specific programmer existing AVR Studio installation to get required device parameters. This means that AVROSP automatically supports all devices supported by AVR Studio. No update is required for future AVR devices other than keeping your AVR Studio installation up to date.

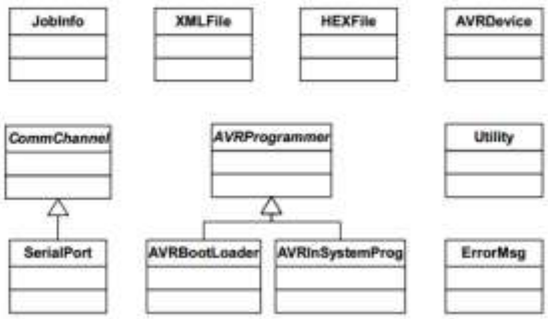
B. Implementation:

This section assumes that the reader has some knowledge of object.

AVROSP Class diagram

The functionality of the building blocks of the system is described next. The data source e.g. (speed sensor) reads the speed of the vehicle. The speed data from the sensor is peak to peak AC voltage so it will be converted to DC voltage to be readable by the microcontroller.by microcontroller (e.g. to compare between the current and previous speed). New processed data will then be transmitted to the LED driver. LED driver will make the current constant to protect LED. Then, data will transmit by the LED Light as carrier. Upon data transmission wirelessly
Through the light, the photodiode will detect the transmitted light in form of current. The table 1 shows the AVR OSP classes.

Table 1 AVR OSP classes



Trans-impedance amplifier function is used to convert the received current into voltage. Finally voltage will be processed through microcontroller to be readable by the LCD more scenarios will be applicable. For the time being, only two scenarios will be studied in this paper.

(A) First Scenario

In Figure 2 shows the first scenario of vehicle to vehicle communication system using Li-Fi, when vehicle 1 is braking, the speed meter in the vehicle will be sensing that the current speed is lower than the previous speed. Thus, a message will be sent through the transmitter which is placed in the rear lights to vehicle 2. The message will be received by vehicle 2 using the photodiode which is placed at the front of vehicle 2. A notice of (Slow DOWN) will be displayed in vehicle 2 using an LCD [8]-[9].

Figure 2: First scenario of vehicle to vehicle communication using Li-Fi

(B) Second Scenario

In Figure 3 shows the second scenario of vehicle to vehicle communication system using Li-Fi, when vehicle 1 is in T- junction, it will keep sending its speed-information to vehicle 2 using the LED at the headlights. The speed-information will be received by the photodiode in vehicle 2 and compared to vehicle 2 speeds. If vehicle 2 is about to cross the junction while vehicle 1 is moving with a high speed [10].

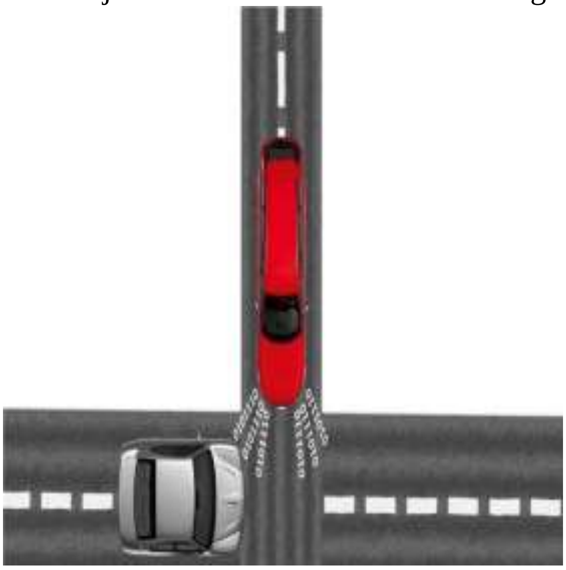


Figure 3: Second scenario of vehicle to vehicle communication using Li-Fi

III. SYSTEM DIAGRAM

The block diagram of the system is shown in figure 4. The functionality of the building blocks of the system is described next. The data source e.g. (speed sensor) reads the speed of the vehicle. The speed data from the sensor is peak to peak AC voltage so it will be converted to DC voltage to be readable by the microcontroller. Then the data will be processed by microcontroller (e.g. to compare between the current and previous speed). New processed data will then be transmitted to the LED driver. LED driver will make the current constant to protect LED.

Then, data will transmit by the LED light as carrier. Upon data transmission wirelessly through light, the photodiode will detect the transmitted light in form of current. Trans-impedance amplifier function is used to convert the received current into voltage. Finally voltage will be processed through microcontroller to be readable by the LCD. T junction, it will keep sending its speed-information to vehicle 2 using the LED at the headlights. The speed-information will be received by the photodiode in vehicle 2 and compared to vehicle 2. The Figure 4 and Figure 5 show the block diagram of transmitter and receiver.

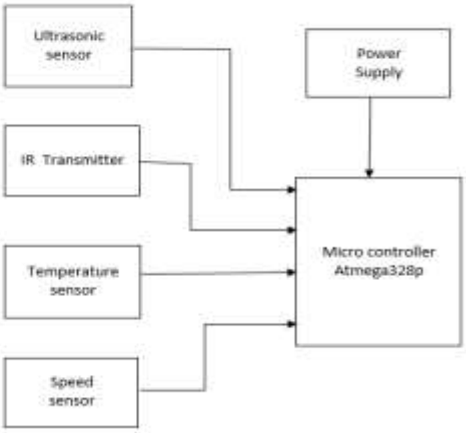


Figure 4: Block diagram of transmitter

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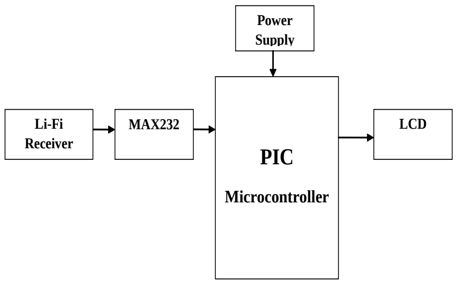

Figure 5: Block diagram of receiver

Receiver:
Initially, a basic receiving and transmitting circuits were implemented and simulated. The purpose of implementing the circuits is to understand the main and basic concepts of optical wireless communication using LED as transmitter and a photodiode as receiver. The voltage, representative of data from the source, is changing between 0 V and 5 V. When voltage is low, there will be no current passing through the LED. Thus, the LED should be off. Similarly, when the voltage is high, the current will pass through the LED. Consequently, the LED is on. Note that the LED driver is used here in order to improve the illumination of LED so that the transmitting distance would be longer [11]-[13].
Besides that, LED driver will regulate the current. The simulated to compare the output of the implemented system and the simulated system, as the photodiode was replaced by a current source and a capacitor. The photodiode output current is a linear function of light intensity which is usually small.

Based on the numerical results, the target of regulating the current was achieved, as evident from figure 8. The current was around 300 mA as it designed for. The voltage was changing between low and high C below. The output had high and low levels which can be detected as zeros and ones. Thus, the major requirement of the system was achieved. However they obtained output is not clear enough to be used as input to a digital system. This problem would be solved by the filters and high precision TIA which were already implemented in the chosen TIA chip.

System Implementation
Since the transmitting and receiving systems cannot be tested as whole via simulation, experimental testing in the lab was done. The basic circuits were tested to prove the functionality of the chosen LED and photodiode. The blinking of the LED was detectible at frequencies lower than 1 kHz unlike frequencies above 1 kHz which made the LED seems like constantly on. Thus frequencies higher than 1 kHz must be used in the proposed system [14]-[16].

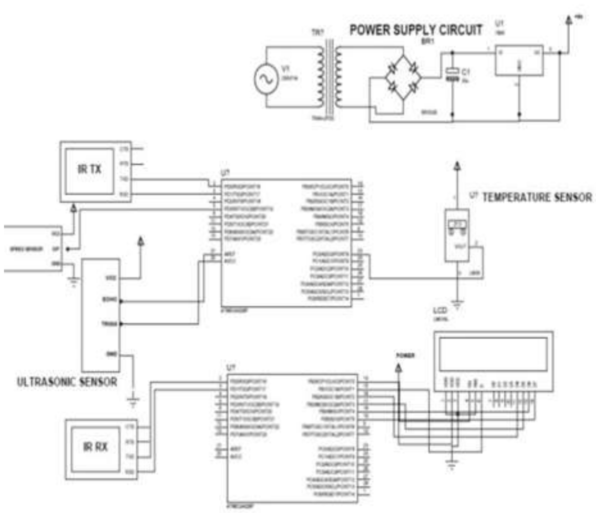

Figure 6: Hardware circuit diagram of Li-Fi

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This project consists of power circuit, IR sensor, Ultrasonic sensor, Temperature sensor, LCD Display. In power supply circuit initially give in 230v ac supply. It is converting to the step down transformer used to 12v ac supply. Then diode bridge rectifier is used to convert ac supply into dc supply. The IC regulator is used to 12v supply to 5v dc supply. The 5v dc supply given to the Atmega328 microcontroller. The output voltage of the receiving circuit was about 5 V when the LED was close to the receiver while it decreased as the transmitting distance increased [17], [18]. The output of the system was quite good in terms detecting levels of data as being ON or OFF, although it decreased with the increment of distance but it was still good enough to be used in processing and applications. The output of the system had some noise since there were no filters used yet in this phase of the project. The Figure 6 shows the hardware circuit diagram of Li-Fi.

The system will be improved further to provide better quality of output. A complete prototype will also be implemented and tested in a small-scale vehicle to vehicle communication to investigate effectiveness of the system in the mentioned scenarios, a new technology that was developed in the last few years, which still needs more investigations on its sustainability for outdoor vehicular networks that has been used in order to reduce vehicles' accidents.

IV. CONCLUSION

In this work, the concept of Li-Fi had been introduced along with existing techniques and classical trends used for vehicle to vehicle communications. The proposed system has a cost effective solution to reduce accidents. The design guidelines and details of system components were thoroughly explained in this paper. The proof of concept has been illustrated in this paper by sending data through Li-Fi small-scale prototype model. Finally the result has been measured between the vehicles to vehicle.

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