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VISIBLE LIGHT COMMUNICATION SYSTEM BETWEEN MOTOR VEHICLES

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Abstract: *In order to prevent traffic accidents the interest is to find efficient warning systems. The aim o the paper is to present TWS (Traffic Warning System), a device that signals the presence of special traffic situations. The information is transmitted through the visible light spectrum (VLC) giving useful information to the driver.*

Key words: *motor vehicle safety, light, communication, traffic, transmitter, receiver*

1. INTRODUCTION

Although cars have been developing continuously, implementing new safety systems, the number of accidents is steadily increasing. For example, in the USA, according to the National Highway Traffic Safety Administration(NHTSA), there was an increase in accidents by 7% in 2015 compared to the previous year, up to 35092 accidents [1, 2].

In order to reduce the number of accidents the worldwide interest is increasing in finding safety systems for this purpose. Paper [2] is studind in vehicle decision support systems (DSSs) which can provides to drivers warning about accident hotspots, based on location analytics. This kind of systems can have an important improvement on driver behaviours, dependind at the same time on their personality.

Safety systems such as car-mounted cameras or radar have proven not to be the most efficient systems and often can not prevent a conflict situation. To have an impact on drivers, safety systems need to provide concrete driver support, based on recognition and tracking about special situations [3, 4, 5].

Other kind of driver assistance are based on cooperative perception, like vehicle to vehicle or vehicle to infrastructure communication [6]. These systems are predictive and have the role of increasing the safety of drivers by signaling special situations encountered in traffic as well as accidents, traffic jams, etc.

With the emergence of fiber optic data transmission, an important channel of information transmission has been opened that successfully replaces existing ones such as electric wire and radio waves. The use of light as a data carrier is also possible without optical fiber, which ensures minimal losses and high immunity to perturbation. This article presents some data transmission experiments using the visible light spectrum as channel.

2. Visible Light Communication (VLC)

This narrow portion of the entire spectrum of light radiation has been chosen, not because it is recommended for transmission efficiency, but for visible spectral devices as a common feature. [7]

The infrared spectrum portion is already devoted to transmitting data for remote controls, but the visible spectrum is used lighting only, not this purpose.

The widespread use of light sources using the LED opens a new transmission channel in the visible light spectrum. Visible light communication gains the interest of researchers because of its unique advantages over radio frequencies. Supporting research into high-efficiency light sources has brought forward complex lighting equipment with LED (Light

Emitting Diode). Practical attempts to explore the possibilities of LEDs in information transmission systems are all the more tempting as modulation possibilities are relatively low and there is a wide range of control and command devices.[11]

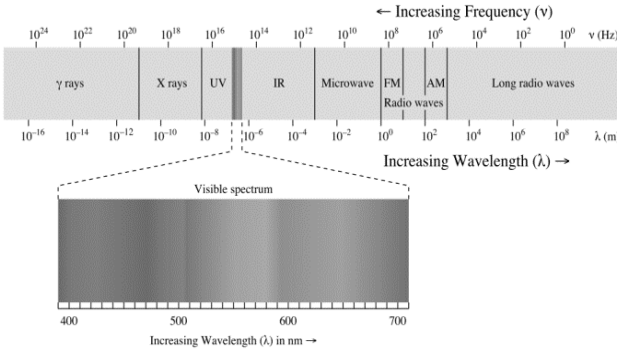

Fig.1 Light spectrum

2.1 Block diagam analysis in a VLC

The simplified model of a link is shown in the figure below. The information produced by the source, in the form of the message m, is transformed by the transmitter into an electrical signal which is further processed in the broadcasting equipment to enable it to be transmitted by the transmission medium, in this case the space limited to the visible horizon.

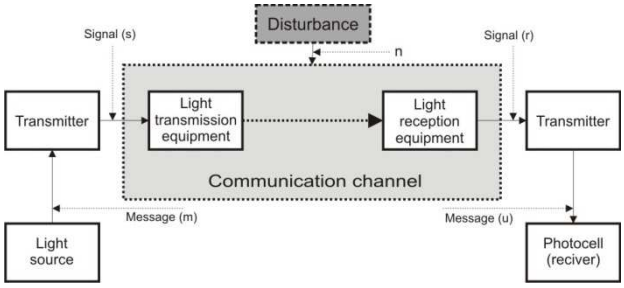

Fig. 2 Block diagram of a VLC system using LED technology

The receiving equipment extracts the r signal from the transmission medium. This signal is a combination of the emitted signal *s* and the disturbances *n* affecting the transmission channel. The transmitting equipment, the transmission medium and the receiving equipment form the communication channel. [9]

3. INITIAL VLC COMMUNICATION MODEL

The simplest receiver of the signals transmitted in the visible light spectrum is a common photodiode connected to the microphone input of a PC. An application with the oscilloscope function that can run on the PC can highlight the existence of signals of various shapes and intensity in the visible light spectrum. The first practical test was through the use of two PCs, a light modulator, and a single photocell receiver. Configuration of the equipment can be seen in figure 3.

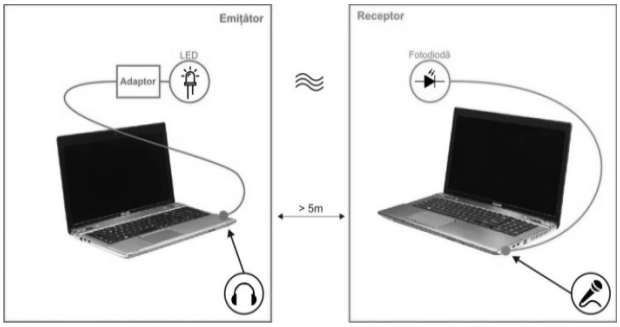

Fig. 3 Experimental model for data transmission using VLC

The signal emitted by one of the PCs on the headphone output, amplified and passed through a small impedance transformer, is emitted by a white LED.

The reception on another PC is provided by a photodiode coupled to the microphone input. The signal in different types of modulation can be received without error from a maximum distance of 5 m.

Modulation seeks to modify the bearer parameter by the modulator signal following a linear law. Such dependence ensures reception of a simple signal recovery (demodulation) at reception. The following types of modulation were used:

- amplitude modulation (MA);
- frequency modulation (MF);
  phase modulation (PSK).
- combined type modulation systems (MA + MP). The best results for signal catchment were obtained using Phase Modulation (PSK).

In this experiment the MixW radio communication software was used to assure the

emission and reception of the signals in the modulation types listed above. This software uses breakout synthesis and numeric filters.

4. PRACTICAL APPLICATION OF DATA TRANSMISSION BY VISIBLE LIGHT

Documentation for the prototype has identified electronic components, including DSP filters, which provide immunity to the transmitted and received signals without compromising the PSK modulation performance.[10]

This is how we can build a prototype that checks remote data transmission using the spectrum of visible light. This prototype with such functions uses the DTMF encoding / decoding mode. The prototype follows the block diagram of a VLC system using LED technology to highlight the possibilities of transmitting data in the visible light spectrum.

4.1 Traffic Warning System – TWS

The Traffic Warning System (TWS) is a device that signals the presence of special traffic situations such as the presence of motorcyclists, accidents or police or rescue vehicles on mission, and other such unpredictable events. The aim of the device is to increase driver vigilance.

The received DTMF codes apply to the Traffic Warning System. This is a device for signaling special situations in traffic, such as the presence of motorcycles, accidents or police vehicles or ambulances on mission and other unpredictable events.

Fig. 4 TWS device

The aim of the device is to increase driver vigilance.

TWS system symbols contain a suggestive image of each signaled situation, as well as a light ring made up of eight segments. They are meant to signal, in pairs of two by two, the direction of action of the identified event.

4.2 Working principle DTMF

DTMF (Dual Tone Multi Frequency) is a signaling system that replaces classic pulse transmission in the telephone network. DTMF is also used in other applications such as phone banking, e-mail, remote phone control, and more. A multifrequency signal (DTMF) is a sum of two suitably chosen sine wave signals for which there are several standards that differ by the number of frequencies chosen and their value. [8]

Fig. 5 Signaling the direction of the event

Most commonly used is the CCITT standard that recommends two frequency groups: a low frequency group (697, 770, 852, 941 Hz) and a high frequency group (1209, 1336, 1477, 1633 Hz). Thus, there are 16 tones, each composed of a line frequency and a column frequency resulting in ten digits (0-9), dots (#), star (*) and four special tones (A, B, C, D).

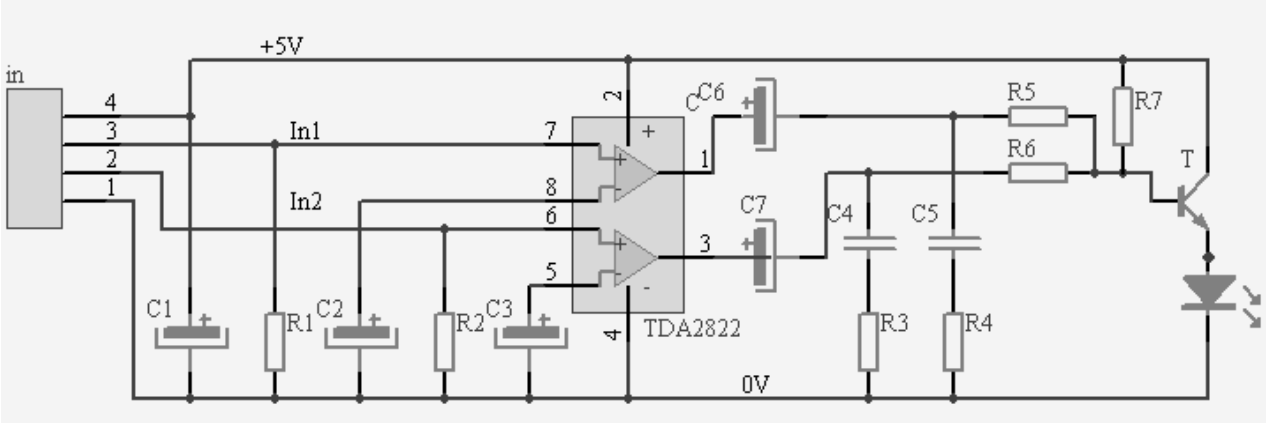

Fig. 6 Electronic scheme of the experimental data transmission model via VLC

Table 1

Frequency/ Code matric for DTMF

	High frequency				
Low frequency	Hz	1209	1336	1477	1633
	697	1	2	3	A
	770	4	5	6	B
	852	7	8	9	C
	941	*	0	#	D

4.3 Transmitted

For the implementation of the generator we did not use specialized circuits, as it can easily be simulated with a PC, with an application installed on a mobile phone, or simply with the keyboard of any phone. To modulate the signal in the visible light spectrum, the assembly in the following figure was used. The assembly is inserted inside an LED lance, which has three 1.5V AA batteries (fig 6).

The transmitter sends a two-tone DTMF tone message that modulates a class A amplifier that powers a LED at a 20mA current.

The torch comes with a finished cable with a 3.5 mm jack plug that connects to audio outputs to a PC or a mobile phone.

4.4 Receiver

The reception of the signal is provided by an electronic assembly with a phototransistor and the HT9170B specialized circuit. The 16 codes that can receive them are sufficient to exemplify the operation of the TWS system.

The HT9170 series is an integrated Dual Tone Multi Frequency (DTMF) receiver with decoding and digital filtering (DSP) functions. All types of the HT9170 series use digital techniques to detect and decode 16 DTMF tones. Tones are available in a four-bit code.

5. THE EXPERIMENTAL MODEL

For experimenting as close to real as possible, there were two cars on which the TWS system was installed (fig.7, 8, 9, 10). One hadthe role of transmitter, and the other had the receiver and the decoder and display equipment installed on board. The five states of the TWS system were simulated using a mobile phone as a DTMF generator.

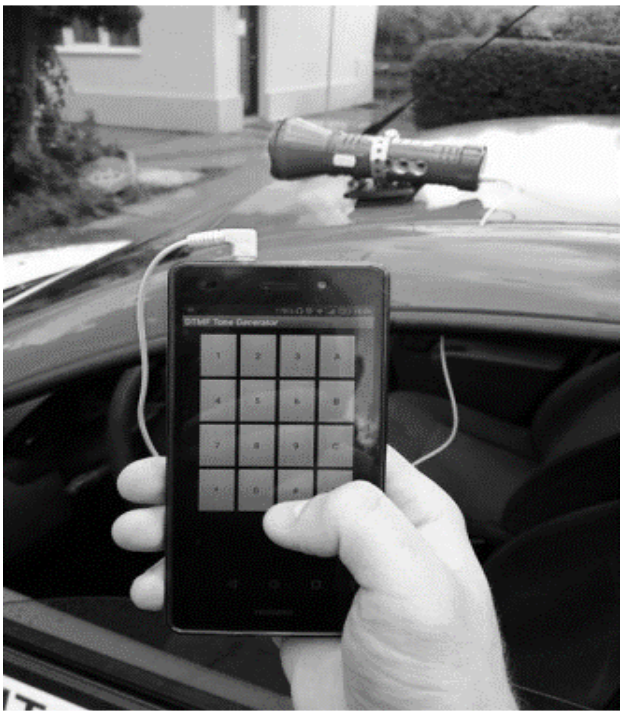

Fig. 7 Transmitter with DTMF

The receiver mounted on the test car is made up of two parts:

• photocell receiver, mounted on a magnetic holder for a better fit on the roof of the car.

• the decoder and display side mounted on the board of the car on a 12V source.

Fig. 8 Transmitter inslatted on the car

The system power supply was made from the on-board 12V socket. With the transmitter transmitting all five codes in a row, there was a reception for each symbol as expected, as can be seen in the following pictures.

Fig.9 The display module installed in the car

Up to 30 m a secure reception was achieved in natural light conditions with clear sky and sunshine. There were no perturbations in reception when the headlights were ignited on different phases on the emitting vehicle.

Fig.10 The decoder installed on the car

6. CONCLUSIONS

Traffic participants can more effectively manage crisis situations if they have an overview of the traffic conditions and, in high risk or incident situations, they are immediately alerted to the presence of such events in the maneuver area, and consequently each vehicle in a crisis situation can signal its presence.

This paper highlights some aspects of the electronic / optical system, that the entire system operation and the electrical and electronic components rely on; the latter serve to the communication between vehicles through the use of appropriate communication protocols. Currently, only radio waves are used in the automotive industry as an information propagation medium. Even if the radio spectrum is not exhausted, it tends towards a cluster of channels on some frequency bands. Given this, a different approach has been chosen, by using

another information propagation medium, such as visible light spectrum (VLC). It is not currently used, the tape is free from other applications, and the cars are equipped with factory lighting, making implementation easier. Compared to a radio communication system, this VLC communication system provides directional information transmission hard to reproduce in radio systems.

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SISTEM DE COMUNICARE ÎNTRE AUTOVEHICULE ÎN SPECTRUL LUMINII VIZIBILE

Rezumat: Pentru a preveni accidentele rutiere, existăun interes constant în găsirea unor sisteme eficiente de avertizare. Scopul cestei lucrări este să prezinte sistemul TWS (Traffic Warning System), un dispozitiv care semnalează prezența unor situații speciale de trafic. Informația este transmisă prin spectrul de lumină vizibilă (VLC) care oferă informații utile șoferului.

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