Exploring Visible Light Technology for Vehicle-to-Vehicle Communications

[1]Elizabeth Eso, [1]Zabih Ghassemlooy, [1]Andrew Burton and [2]Stanislav Zvanovec
[1]*Faculty of Engineering and Environment, Optical Communication Research Group (OCRG), Northumbria University, Newcastle upon Tyne, UK.*
{elizabeth.eso; z.ghassemlooy; andrew2.burton}@northumbria.ac.uk

[2]*Czech Technical University, Czech Republic*

1 Introduction

Visible light communication (VLC) is an evolving technology and has been gaining a lot of attention over the past decade by researchers in both industry and academia. The development of high intensity light emitting diodes (LEDs) devices, which have about ten times the luminous efficiency of the tungsten incandescent lamp, and is constantly increasing [1]. Hence, it is becoming common practice to replace the incandescent and fluorescent lamps used in street lighting and vehicle headlamps with high power LED bulbs. This has generated great opportunities for the telecommunications industry, whereby the LED lighting can be used to create optical wireless communication links between vehicles . The number of vehicles on the roads is on the increase year by year; traffic congestion is becoming an increasingly widespread problem and road traffic crashes are the leading cause of death among young people as issued by the World Health Organisation. Therefore intelligent transport systems (ITS) hold the potential to provide improved capabilities for enhancing traffic movement and safety on roads through the provision of information for safe driving and warnings to drivers. Therefore this research aims to experimentally investigate V2V through VLC. A dedicated testbed will be developed in order to carryout experimental performance verification. The proposed designs of the Vehicular VLC network will be built upon multi-hop transmission enabling the connectivity between vehicles. This will involve the investigation of relaying protocols, and the use of high spectral efficient based signalling such as orthogonal frequency division multiplexing and multiple carrier-less amplitude and phase modulation.

2 System Block Diagram

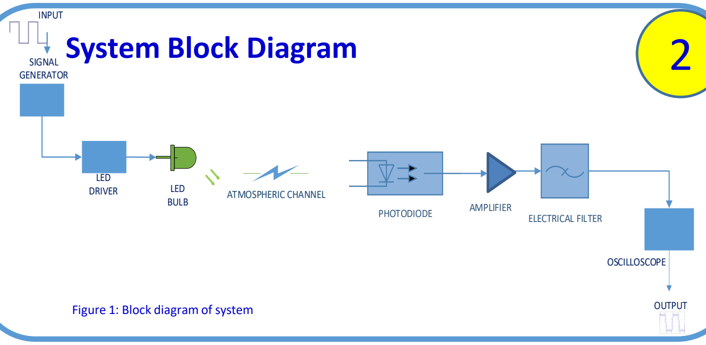

Figure 1: Block diagram of system

3 Vehicle to vehicle (V2V) communications

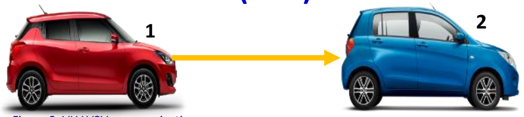

Figure 2: VLV V2V communication

- Vehicle 1 communicates with vehicle 2 using its front head lamp as the transmitter
- Vehicle 2 receives with its rear camera (receiver)

4 Infrastructure to Vehicle (I2V) communication

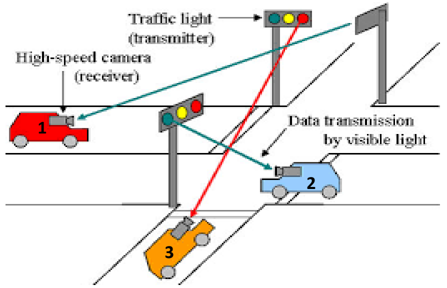

Figure 3: Infrastructure to vehicle communication [2]

- Street lights (infrastructure) communicates with cars 1, 2 & 3
- The cars receive the information using their front camera

5 Application of V2V & I2V communications to ITS

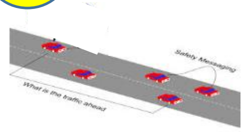

Figure 4: Exchange of messages between V2V [3]

- Messages sent from one car to another to prevent potential crashes and for easier traffic control

6 Modelling VLC communications

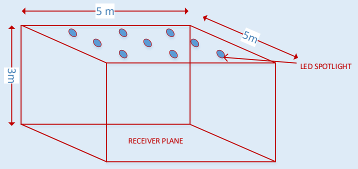

Figure 5: Modelled indoor VLC configuration

The VLC system is to be modelled in MATLAB before the physical implementation will be carried out. Initial modelling of the LED beam profile has been performed using the indoor scenario; considering both the line of sight (LOS) and the reflected (non-LOS) DC gain of the transmitted optical beam. Nine equally spaced transmitters (LED spotlights) have been placed throughout the ceiling, with the results presented in section 7 at the receiving plane (average desk height). This model can then be adapted for the outdoor road situation between vehicles or from the roadside infrastructure.

7 Simulation Results

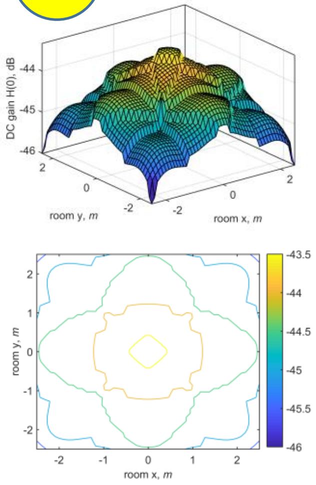

Figure 6: LOS DC gain of the transmitted optical beam at the receiver plane

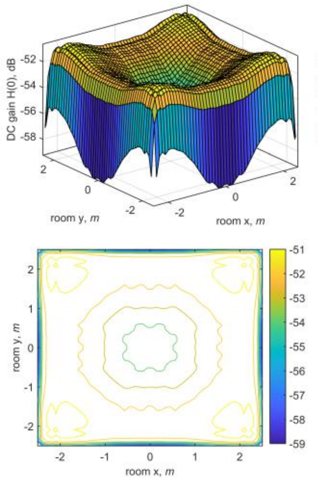

Figure 7: Reflected (non-LOS) DC gain of the transmitted optical beam at the receiver plane

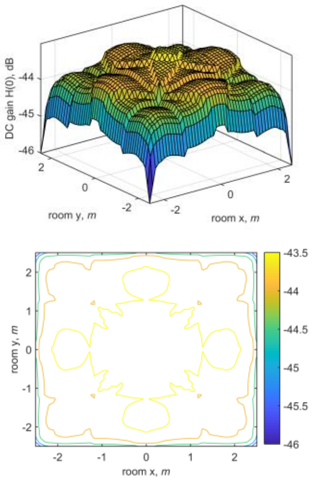

Figure 8: Total DC gain (for both LOS and non-LOS) of the transmitted optical beam at the receiver plane

8 Conclusions and Future Works

Simulation results of the DC gain has been presented which shows the beam profile of both the LOS and NLOS reflected light. Following comprehensive mathematical modelling and simulation, a dedicated experimental testbed will be developed to carry out performance verification of the proposed scheme. Commercially available vehicles headlights/taillights will be used as the light sources (i.e., transmitter) and all physical / medium access control functionalities will be implemented using the field programmable gate array. At the receiver side, optical lens/filters, photodetectors or cameras or hybrid version of the two will be used. The experimental VLC link will be first tested under laboratory conditions. The proposed VLC scheme will also be tested in trains as part of the coach-to-coach communications where the nominal link is less than 2m.

9 References

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