VLCLighting

Visible Light Communications for LED based Public Lighting Systems

Project VLCLighting explored Visible Light Communications concepts, for high speed broadcast services, in public street lighting infrastructures. It delivered a demonstrator transmitting data rates compatible with high definition video services, with great robustness to channel impairments. Also it was built to be modular in order to enable collaboration with other research groups and ease system customization.

Main Project Team	
Mónica Figueiredo	**IC-Av**
Luís Nero Alves	IC-Av
Carlos N. Ribeiro	MN-Av
Adão Silva	MN-Av
Indicators	
Funding	40k €
Journal Papers	2
Conference Papers	4
Book Chapters	1
Concluded MSc	3

Two Main Publications

M. Figueiredo, Carlos Ribeiro, "OFDM based VLC systems FPGA Prototyping", VLC theory and Applications Book Chapter, accepted for publication, CRC Press/Taylor & Francis Group, 2016

M. Figueiredo, C. Ribeiro and L. N. Alves, "Live demonstration: 150Mbps+ DCO-OFDM VLC," "2016 IEEE International Symposium on Circuits and Systems (ISCAS)", Montreal, QC, 2016, pp. 457-457.

PROJECT WEBPAGE URL
http://ic_group.av.it.pt/VLCLighting

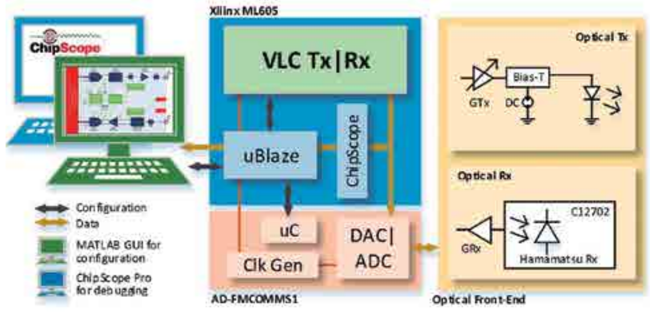

Fig. 1 VLC demonstrator - System Level Architecture.

Fig. 2 Optical Front Ends.

GENERAL MOTIVATION AND OBJECTIVES

Public street lighting can easily represent 25% to 60% of municipality global budget, in developed countries. Current trends in public lighting systems aim for higher efficiency and better quality of light, which demands for solid state lighting devices (LEDs) and smart networking infrastructures with power control strategies, designed to reduce energy consumption while providing comfort and visibility to users. Together, LEDs and smart networking concepts, enable illumination to react to environmental demands by combining sensory information (like motion detection or background illumination). Another possibility to retrieve economical returns and improve efficiency is to offer value added services, such as infotainment and advertising services, using visible light communication (LVC) technology. The mail goal of this project was to help mature this technology by developing a high speed VLC demonstrator based on illumination compatible LEDs with sufficient robustness to channel impairments, so that it could be used to support those services.

CHALLENGE

Using LEDs for both illumination and communication purposes presents new design challenges and opportunities. LEDs for lighting applications usually require high output flux per chip, which translates into high forward currents. Switching these devices pose fundamental limitations on the achievable bandwidth, which constrain the support of high data rate services. Also, high optical power may lead to higher interference levels between neighbouring luminaires. Thus, evolved modulation and coding schemes must be applied. In recent years, OFDM-based modulation schemes have been considered as promising techniques for VLC. Their ability to mitigate the effects of the deep fading of the optical channel and the interference from neighbouring transmitters, while achieving high data rates, justify their adoption in this project. Another promising venue consists of exploring optical digital to analogue conversion (ODAC) promoted by the usage of LED arrays and chip on board LEDs, thus mitigating the LED distortion induced by its non-linear characteristic. Project VLCLighting explored solutions to these challenges, based on OFDM modulation formats and illumination grade LEDs. For this reason, it required a multidisciplinary team with researchers from the Integrated Circuits group and the Mobile Networks group, both from Instituto de Telecomunicações, Aveiro site.

WORK DESCRIPTION AND ACHIEVEMENTS

In VLCLighting, a real-time high-speed VLC prototype transceiver, based on DCO-OFMD, was implemented in a Xilinx Virtex-6 FPGA. The transceiver was designed as a globally asynchronous locally synchronous (GALS) system to improve its flexibility and offer a real-time test bed to evaluate the performance of different modulation schemes and DSP algorithms. Preliminary results, obtained with a single blue LED driven by a commercial amplifier and bias-T, showed that the system can transmit over 2m, with a 12 MHz bandwidth using QPSK, thus achieving 24 Mbit/s with a bit error rate (BER) lower than the $3.8 \times 10\text{-}3$ forward error correction (FEC) limit. For shorter distances, e.g. 50cm, and a luminaire based on white LEDs, the system was able to transmit at 150 Mbps, using 64-QAM and 25 MHz bandwidth. Moreover, under this project's framework, two optical frontends were develop: 1) a single LED driver in class AB, with an analogue pre-emphasis circuit; and 2) an 8-bit ODAC driver. The single driver enables us to modulate a high efficiency illumination compatible LED within an extended usable bandwidth up to 100MHz. The ODAC eliminates the need for an electrical digital to analogue converter, but has a much smaller usable bandwidth (only up to 12MHz). Results with the ODAC were obtained for QPSK only, with a maximum data-rate of 30Mbps at 60cm. Results for the single LED driver haven't yet been obtained. However, and given the available 100MHz bandwidth, we expect to achieve at least 300Mbps at the same distance.