OPTICWISE NEWSLETTER

Optical Wireless Communications - An Emerging Technology
COST Action IC1101

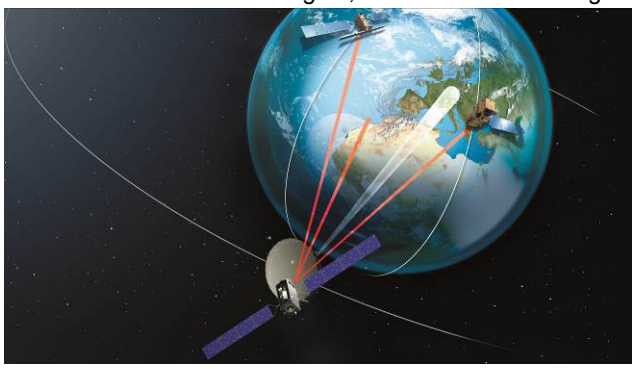
Issue 4

Editor's Note

It is now just a matter of time when optical wireless communications (OWC) will be transformed from an emerging to an enabling and routine technology in our lives. All over the world when big initiatives and industrial bodies announce world spanning wireless networks, for instance Facebook and Google, OWC is in discussion. The first real commercial system for long range optical communications will even be in operation very soon: the European Data Relay system.
Florian Moll, Editor of the newsletter

OPTICWISE Highlights

One big step towards commercialization of Optical Wireless Communications (OWC) are the successful transmission tests between the European communication satellite Alphasat I-XL, in geostationary orbit, and the Earth observation satellite Sentinel 1A, in low Earth orbit. Both spacecraft have a laser communication terminal on board. The technology will soon be used in the European Data Relay System, which uses the laser link to transmit data from near Earth satellites to the geostationary data relay.
The commercial character of OWC is also lifted by industry initiatives and standardization activities: OPTICWISE was admitted as an Associate Member of the 5G Infrastructure Public-Private Partnership (5G PPP). It became the first non-legal entity to be admitted to this visionary initiative which will shape the next generation wireless networks. Furthermore, OPTICWISE participates in the preparation of a new IEEE standard on OWC. A task group prepares now a standard on short range systems. This would be a revision to the earlier Visible Light Communications standard IEEE 802.15.7-2011 and accommodate infrared and near ultraviolet wavelengths, in addition to visible light.



Concept of EDRS system. Source: DLR.

This Issue

Meetings and Workshops

The Action's **6th Management Committee (MC) meeting and Working Group (WG) meetings** were held at Grazer Messe in Graz, Austria on July 7-9, 2014. The 16th International Conference on Transparent Optical Networks (ICTON) ran in parallel. The agenda was quite versatile and included MC/WG meetings as well as several joint ICTON-OPTICWISE sessions. During the WG meetings, nine scientific and technical input documents were presented and discussed. The content covered Tbps-systems, beam shaping with spatial light modulators, low-cost platforms for distributed evaluation of OWC, influence of ash and dust on the optical link in combination with turbulence, scintillations in underwater medium, all-optical dual hop links in turbulence, simulations and investigations of RoF systems and indoor high-speed OWC. Special insight into work ongoing at Delft University, Netherlands, was given by Prof Marco Zuniga in the invited talk on *Embedded Visible Light Communications*. A second invited talk was given by Prof Stefano Taccheo as the Chair of the new COST Action on *Advanced Fibre Laser and Coherent Source as Tools for Society, Manufacturing and Lifescience* (MP1401). He reported on the motivation, scope, ongoing activities of this Action and the possible benefit for optical wireless communications.
The **7th MC/WG meeting** took place just a few months later, on the Madeira Island, Portugal, in September 17-19, 2014. This time it was organized together with the **3rd International Workshop on Optical Wireless Communications (IWOW)** and collocated with Networks 2014. The program incorporated four very interesting sessions on Free Space Optics and Visible Light Communications. A total of 18 talks were delivered by authors coming from all over Europe, China, USA and Saudi Arabia (just to tell a few). The talks discussed

research outcomes on multiuser diversity in OWC, mixed RF/FSO systems, laser signal characterization, field correlation in the atmospheric channel, cloud obscuration in the space-ground scenario, channel modelling with radio sounding data, VLC networks, indoor communications and positioning, amongst others. The WG meetings were supported by eleven input documents which were presented and discussed. These presentations ranged from channel characterization (turbulence, rain and fog), beam steering devices, LTE over FSO, backhauling, mid-IR wavelengths and open-source wireless optical systems for global experimental deployment.

Joint keynote speech by Peter Chochrane on the The Infinite Security of Clouds during 3rd IWOW and Networks 2014.

The meeting also hosted two invited talks. One was given by Dr Martin Siegel, Head of Technology Experts & Scouting Zumtobel group, Portugal, on *Visible Light Communication & Professional Lighting*. He presented the scope of the company, outlined the professional lighting market and how VLC can be included in professional lighting. The second invitation addressed the company ViaLight Communications, a start-up from the German Aerospace Center (DLR), and its view on the commercial potential of OWC. The talk *Laser Communication Systems for Aerial Platforms – from Perspective of a Start-up in Mobile-FSO* was given by the company's co-founder Dr Dirk Giggenbach.

The Special Interest Groups (SIGs) also reported their progress. The SIG on Visible Light Communications (VLC) is working on a dedicated book on VLC. It is planned that the first part of the book will be written by Action participants while the second part will consist of chapters which will be collected through an open call. This will be one of the very first books which will focus only on VLC.

The **8th MC meeting** was held in Berlin, Germany, at the Fraunhofer Heinrich-Hertz Institute (HHI) on March 13, 2015. In this single day event, no WG meetings took place. A welcome speech was given by the Head of the Department of Photonic Networks and Systems, Dr Ronald Freund. After that Prof Murat Uysal and Dr Volker Jungnickel informed the MC members about the OPTICWISE's participation in IEEE 802.15.7 standardization activities. Through OPTICWISE involvement, the scope of the new task group responsible for the development of standard was extended from "optical camera communications" to "optical wireless communications". After the presentations, HHI presented the main facilities and related lab setups: an indoor VLC testbed of a smartphone and room lamp, an outdoor 200 m test link for availability analysis and a sound cinema. During the meeting, the MC also did some housekeeping issues and discussed the format of the Final Action publication, a book that shall reflect the work what was done within the framework of the Action.

OPTICWISE group photo in front of Fraunhofer HHI in Berlin.

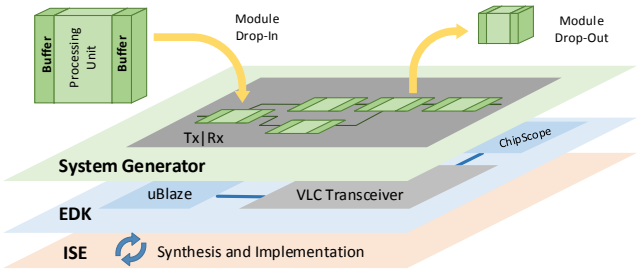
News from the Working Groups

The scientists from the Cankaya University, Turkey, were very active in the **SIG UW-OWC (Special Interest Group Underwater Optical Wireless Communications)**. The researchers' expertise in theoretical description of the propagation channel and characterization of communication performance will now be extended by experimental investigations in a new laboratory that they will build with support from Turkish Research Council, TÜBİTAK. In the framework of their project named "Underwater Optical Wireless Telecommunication System Design and Application" they aim to develop a realistic way to emulate the underwater environment within an indoor aquarium. The group also investigates the use of spatial light modulators for beamforming of laser and LED signals in this scenario. Beams of Gaussian, flat-topped and Bessel like shapes were already tested. Furthermore, they plan to investigate the effect of channel coding techniques on the bit-error rate in the underwater channel to increase robustness and link availability. The project started in the beginning of 2014 and will end in mid of 2016. Several papers were already published containing the results of the recent investigations such as *Structure functions for optical wave propagation in underwater medium (Yalçın Ata and Yahya Baykal, 2014)*, *Bit error rate of focused Gaussian beams in weak oceanic turbulence (Hamza Gerçekcioğlu, 2014)*, *Wave structure function and spatial coherence radius of plane and spherical waves propagating through oceanic turbulence (Lu Lu, Xiaoling Ji, and Yahya Baykal, 2014)* and *Field correlation of spherical wave in underwater*

turbulent medium (Yalçın Ata and Yahya Baykal, 2014).

Aquarium lab at the Cankaya University with setup of measurement range. Source: Cankaya University

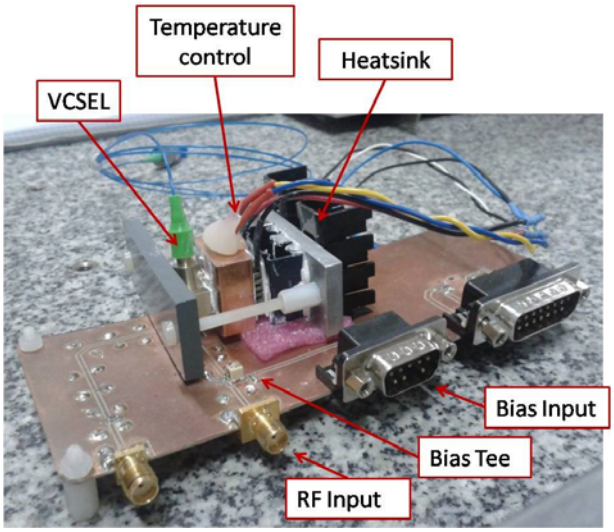
Another interesting project is ongoing at the Instituto de Telecomunicações, Aveiro site, Portugal. It is a collaborative research project aiming at the exploitation of VLC concepts for broadcast services in lighting infrastructures. It is being developed by the Integrated Circuits and Mobile Network groups and expects to deliver a VLC demonstrator capable of transmitting video streams and data in real-time by the end of 2016. One of the main specifications of this system is to be modular in order to enable collaboration with partners, offering the academic community a real-time test bed to evaluate the performance of different modules, algorithms and optical front-ends. This demands the transceiver's architecture to be modular in order to ease the adding/removing of modules developed by the partners. Different modulation schemes and signal processing units can therefore be easily tested, their performance evaluated and compared to alternative solutions. To this end, the interface between the main blocks includes elastic buffers that implement an asynchronous handshake protocol. As long as this architecture is respected, it is very straightforward to add/remove blocks without concerns about synchronization and latencies. The VLC transceiver is being implemented in a Xilinx Field Programmable Gate Array (FPGA). Beyond usual advantages of prototyping with FPGAs, it is especially suited for this project because of: (1) the availability of system level tools (e.g., Xilinx System Generator) that eases the hardware design learning curve, especially for researches used to MATLAB and Simulink for algorithm design; (2) the easiness of introducing new modules, and testing their performance in simulation, co-simulation and real-time; (3) the availability of sophisticated hardware debug tools, such as Xilinx ChipScope Pro; (4) the reasonable cost when compared to existing VLC demonstrators (relying on arbitrary waveform generators); and (5) the possibility to integrate the transceiver with a microprocessor with Linux support (e.g., Microblaze) which enables full system integration with high level data services. Processing units are developed within System Generator; the transceiver's integration with MicroBlaze and ChipScope modules is performed in EDK; and finally, synthesis and implementation steps are performed in ISE.



Software development flow and Xilinx tools used in the VLC test-bed. Source: Aveiro University.

The test-bed system level architecture comprises the VLC transceiver implemented in the FPGA, a DAC/ADC board and an optical front-end. The optical transmitter can be based on a single LED or a LED matrix. The VLC transceiver and analog modules are easily configured via MicroBlaze using a MATLAB Graphical User Interface (GUI). For debugging and testing purposes, ChipScope Integrated Logic Analyzers modules are used.

The Department of Electronics Technology at Carlos III University, Spain is active with a project for development of high-efficiency, low-power consumption, low cost, multimode optical sources for optical wireless communications. Optical Frequency Combs Generators (OFCG) have found applications in many fields, including optical communications, as multicarrier light sources, but their deployment for optical wireless communications must be associated to the achievement of compact, low-cost and low power consumption transmitters. Towards this end, the researchers have provided with a suitable multicarrier low-cost light source based on a novel implementation of an OFCG using VCSELs and without the need of external electrooptic modulators. Also, in collaboration with the Communications Group of the same university the researchers have analyzed a proposal based on fuzzy logic for reducing the peak to average power ratio in optical multi-carrier-based modulation.



Vertical-cavity surface-emitting laser (VCSEL) based, optical frequency comb generator (OFCG). Source: Carlos III University of Madrid

Member Profiles

Mohammad Ali Khalighi, Vice Chair of WG2, received his PhD degree in Telecommunications from Institut National Polytechnique de Grenoble, Grenoble, France, in 2002. He joined École Centrale Marseille and Institut Fresnel in 2005, where he currently holds an Associate Professor position. His main research areas of interest include signal processing for wireless communication systems with an emphasis on the physical layer aspects of free-space, underwater, and indoor visible-light optical communications. So far he has co-authored more than 70 journal and conference papers on these topics.
Dr. Khalighi is the recipient of the Scientific Excellence Award from the French Ministry of Research and Higher Education for the periods of 2009–2013 and 2013–2017.

MARTA RUIZ LLATA, *Vice Chair of WG4, received the Ph.*D. in Electrical and Electronics Engineering in 2005 from Universidad Carlos III de Madrid for her work on optical implementation of neural networks. Since 2011 she is Associate Professor within the Electronics Technology Department at Universidad Carlos III de Madrid. Her research projects are being involved in the development of optical sensors for industrial and environmental applications and the investigation of machine learning algorithms in instrumentation systems. The activities of her research group also include the design and development of optoelectronic/laser Instrumentation Systems, Design and Characterization of Lasers and Photonic Integrated Circuits and Design of Optical Architectures for optical signal generation and processing.

Slavisa Aleksic, *Vice Chair of WG3*, received both Dipl-Ing. (M.Sc.) and Dr. techn. (Ph.D.) degrees from Vienna University of Technology, Austria in 1999 and 2004, respectively. He worked for several companies such as Unioninvest, Unis-Unidata, and Steinbeis Temming in different positions. Since 1998 he has been working at the Vienna University of Technology in different positions and with several institutes. Currently, he is with the Institute of Telecommunications, where he is involved in teaching and research activities within the broad area of communication systems and networks.

Upcoming Events

- 21st ka and Broadband Communications Conference, 12-14 October, 2015, Bologna, Italy.
- IEEE Military Communications Conference (MILCOM), 26-28 October, Tampa, USA.
- International Conference on Space Optical Systems and Applications (ICSOS), 27-28 October, 2015, New Orleans, USA.
- IEEE Global Communications Conference (GLOBECOM), 6-10 December, San Diego, USA.
- SPIE Photonics West Free-Space Laser Communication and Atmospheric Propagation XXVIII, 13-18 February, 2016, San Francisco, USA.
- Optical Fiber Communication Conference and Exhibition (OFC), 20-24 March, 2016, Anaheim, USA.
- SPIE Photonics Europe, 4-7 April, 2016, Brussels, Belgium.
- SPIE Astronomical Telescopes and Instrumentation, 26 June - 1 July, 2016, Edinburgh, UK.
- 18th International Conference on Transparent Optical Networks (ICTON2016), 10-14 July, 2016, Trento, Italy.
- 7th International Conference on Optical Communication Systems (OPTICS 2016), 26-28 July, Lisbon, Portugal.

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