

## **Working Group 1, Milestone M1.2**

### **VLC system implementation and evaluation systems**



## Introduction

Based on the overall goal of WG1 to develop point-to-point and high performance OWC based solutions for ultra-high-speed links for sub-metre applications, Milestone 1.2 has been accomplished, as demonstrated in the internal documents discussed in the project meetings as well as publications, see the list below.

### 1. Input documents

- Vaigai Nayaki Yokar, Hoa Le Minh, Zabih Ghassemlooy, Wai Lok Woo, Luis Nero Alves, and Tran The Son, “Data Rate Enhancement using CNN Neural Network in a Smartphone-to-Smartphone Visible Light Communications System”
- Luís Rodrigues, Mónica Figueiredo, Luís Nero Alves, Zabih Ghassemlooy, “Carrier synchronization in m-CAP modulation for VLC-based IoT systems”
- Vicente Matus, Marco Fernandes, Fernando Guiomar, Jose Rabadan, Luis Nero Alves, Paulo Monteiro, “Application of Image Stabilization Algorithms to Optical Camera Communication Links in Turbulent Environments”
- Vicente Matus, Shivani Rajendra Teli, Lidia Aguiar-Castillo, Jose Rabada, Stanislav Zvanovec, Rafael Perez-Jimenez, “A Practical Teaching Tool for Optical Camera Communications”
- Eleni Niarchou, Klara Eollosova, Vicente Matus Icaza, Jose Rabadan, Rafael Perez Jimenez, Stanislav Zvanovec, “Experimental evaluation of LED-based wearable transmitters for optical camera communications systems”
- Behnaz Majleseini, Callum T. Geldard, Victor Guerra, Julio Rufo, Wasio O. Popoola and Jose Rabadan, “Empirical Study of Underwater-Air Optical Camera Communication System under Dynamic Surface Waves”
- Hamza Dely, Mahdieh Joharifar, Xiaodan Pang, Djamel Gacemi, Toms Salgals, Richard Schatz, Yan-Ting Sun, Thomas Bonazzi, Etienne Rodriguez, Yanko Todorov, Angela Vasanelli, Aleksejs Udalcovse, Sandis Spolitis, Vjaceslavs Bobrovs, Oskars Ozolins, Sergei Popov, and Carlo Sirtori, « High bitrate data transmission in the 8-14  $\mu\text{m}$  atmospheric window using external Stark-effect modulator with digital equalization”
- Mahdieh Joharifar, Mengyao Han, Richard Schatz, Rafael Puerta, Yan-Ting Sun, Yuchuan Fan, Grégory Maisons, Johan Abautret, Roland Teissier, Lu Zhang, Sandis Spolitis, Muguang Wang, Vjaceslavs Bobrovs, Sebastian Lourduoss, Xianbin Yu, Sergei Popov, Oskars Ozolins, Xiaodan Pang “8.1 Gbps PAM8 Long-Wave IR FSO Transmission using a 9.15- $\mu\text{m}$  Directly-Modulated QCL with an MCT Detector”
- “Development of a bit error rate test platform for packet-based Visible Light Communications for IoT scenarios”, Luís Rodrigues, Mónica Figueiredo, Luís Nero Alves, Zabih Ghassemlooy
- “Electro-optical SNN using an Enhanced Optical Axon with PAM and Automatic Gain Controller”, George-Iulian Uleru, M. Hulea, Othman Isam Younus, Z. Ghassemlooy, Sujana Rajbhandari
- “Enhancing P300-Based Brain-Computer Interfaces with Hybrid Transfer Learning: A Data Alignment and Fine-Tuning Approach”, S. Kilani, S. N. Aghili, M. Hulea

- “Smartphone Beam Profile in a Screen-to-Camera-based Optical Communication System”, Vaigai Nayaki Yokar,
- “Reflective Type Multi-Nanolayer Electro-Optical Modulator for Free Space Chip-to-Chip Optical Interconnection: Electromagnetic Modelling by the Method of Single Expression”, Hovik V. Baghdasaryan, Tamara M. Knyazyan, Tamara T. Hovhannisyan, Gurgen R. Mardoyan, Tigran Baghdasaryan, Erich Leitgeb, Marian Marciniak.
- “Direct Laser Writing of Photonic Waveguide Components and Interconnects in Polymer”, Tigran Baghdasaryan, Koen Vanmol, Francis Berghmans, Hugo Thienpont, Jürgen Van Erps.
- G.-I. Uleru, M. Hulea, O.I.Younus, Z. Ghassemlooy, S. Rajbhandari, “Pulse amplitude modulation for neuromorphic sensors with VLC”
- Carlos Iván del Valle Morales, Othman Isam Younus, Yongtao Qu, Zabih Ghassemlooy, Juan Carlos Torres Zafra, Iñaki Martínez-Sarriegui, José Manuel Sánchez-Pena, “Characterization of a Perovskites Photovoltaic-based Optical Receiver”
- Luis Abade Rodrigues, Mónica Figueiredo, Luis Nero Alves, “Implementation of Frame Synchronization Architecture for Visible Light Communications in IoT Scenarios”.
- Namarig Mohamed Taha et al., “High-Speed IoT Networks in Healthcare”
- Christos Giachoudis, Vasilis K. Papanikolaou, Sotiris A. Tegos, Panagiotis D. Diamantoulakis, George K. Karagiannidis, R. Schoeber, S. Zvanovec, Ali Khalighi, MAC layer design considerations for optical wireless body-area networks
- Tigran Baghdasaryan, Koen Vanmol, Francis Berghmans, Hugo Thienpont, Jürgen Van Erps, Ultra-Compact 3D-Printed 1x4 Splitter for Multi-Core Optical Fibers
- Eleni Niarchou, Vicente Matus, Rafael Perez-Jimenez, Jose Rabadan, Victor Guerra, Experimental Evaluation of Wearable LED Strip for Outdoor Optical Camera Communications Systems
- Carlos Ivan del Valle Morales, Othman Isam Younus, Juan Sebastian Betancourt Perlaza, Juan Carlos Torres Zafra, Zabih Ghassemlooy, Inaki Martinez-Sarriegui, Jose Manuel Sanchez-Pena, A VLC system for UHD audio-visual content transmission in public transportation
- George-Iulian Uleru; Alexandru Barleanu; Mircea Hulea; Zabih Ghassemlooy, PV powered neuromorphic sensors with optical connectivity

## 2. Publications

- H. Baghdasaryan, T. Knyazyan, T. Hovhannisyan, G. Mardoyan, T. Baghdasaryan, H. Ivanov, P. Bekhrad, M. Marciniak, E. Leitgeb, Transmission Type Nano-Layered Electro-Optical Modulator for Chip-To-Chip Optical Interconnection: Electromagnetic Modelling by the Method of Single Expression, International Conference on Broadband Communications for Next Generation Networks and Multimedia Applications (CoBCom), Graz, Austria, 2022, Vrije Universiteit Brussel Belgium, Graz University of Technology Austria, National Institute of Telecommunications Poland.
- T. Kamalakis, Z. Ghassemlooy, S. Zvanovec, L. Alves, M. Khalighi, Optimization and design of a diffuse optical wireless sensor network, Applied Optics, Vol. 61, No. 22, pp. 6599 - 6599, July, 2022.

- Luis Rodrigues, Mónica Figueiredo, Luis Nero Alves, Zabih Ghassemlooy, “Carrier synchronisation in multiband carrierless amplitude and phase modulation for visible light communication-based IoT systems”. *IET Optoelectron.* 1– 9 (2023).
- Vaigai Nayaki Yokar, Hoa Le Minh, Zabih Ghassemlooy, Othman Isam Younus, Luis Nero Alves, Wai Lok Woo, Turkey Almutairi, “Smartphone Beam Profile in a Screen-to-Camera-based Optical Communication System”, 2023 17th International Conference on Telecommunications (ConTEL).
- G.-I. Uleru, M. Hulea, O. I. Younus, Z. Ghassemlooy, S. Rajbhandari, Electro-optical SNN using an Enhanced Optical Axon with PAM and Automatic Gain Controller, *IET Optoelectronics*, 2023, under review.
- S. Kilani, S.N. Aghili, M. Hulea, Enhancing P300-Based Brain-Computer Interfaces with Hybrid Transfer Learning: A Data Alignment and Fine-Tuning Approach. *Appl. Sci.* 2023, 13, 6283.
- L. A. Ruiz-Preciado, P. Pesek, C. Guerra-Yanez, Z. Ghassemlooy, S. Zvanovec, G. Hernandez-Sosa, Inkjet-printed High-performance and Mechanically Flexible Organic Photodiodes for Optical Wireless Communication, *Scientific Reports*, vol.14, 3296, 2024.
- C. I. Del Valle Morales et al., "Characterization of a Perovskites Photovoltaic-based Optical Receiver," 2023 South American Conference On Visible Light Communications (SACVLC), Santiago, Chile, 2023, pp. 94-99, doi: 10.1109/SACVLC59022.2023.10347709.
- V. N. Yokar, H. Le-Minh, L. N. Alves, S. Zvanovec, W. L. Woo and Z. Ghassemlooy, "Non-Blind Image Restoration Technique in Screen-to-Camera based Optical Camera Communications," 2024 7th International Balkan Conference on Communications and Networking (BalkanCom), Ljubljana, Slovenia, 2024.
- L. Rodrigues, M. Figueiredo, L. N. Alves and Z. Ghassemlooy, "Visible Light Communication Systems Architectures for the Internet of Things," 2023 IEEE 9th World Forum on Internet of Things (WF-IoT), Aveiro, Portugal, 2023.
- G. -I. Uleru, A. Barleanu, M. Hulea and Z. Ghassemlooy, "PV powered neuromorphic sensors with optical connectivity," 2024 7th International Balkan Conference on Communications and Networking (BalkanCom), Ljubljana, Slovenia, 2024.
- Christos Giachoudis, Konstantinos G. Rallis, Ali Khalighi, Vasilis K. Papanikolaou, Sotiris A. Tegos, Panagiotis D. Diamantoulakis, Robert Schober, George K. Karagiannidis, “On the Application of Slotted ALOHA in Optical Wireless Body Area Networks”, 2024 7th International Balkan Conference on Communications and Networking (BalkanCom), Ljubljana, Slovenia, 2024.
- Christos Giachoudis, Mohammad Ali Khalighi, Stanislav Zvanovec, Vasilis K. Papanikolaou, Sotiris A. Tegos, George K. Karagiannidis, “Investigation of Suitable MAC Protocols for Optical Wireless Body-Area Networks”, 2024 14th International Symposium on Communication Systems, Networks and Digital Signal Processing.
- Luís Rodrigues, Mónica Figueiredo, Luís Nero Alves, Zabih Ghassemlooy, “A Packet-based Analog m-CAP Visible Light Communication System for Internet of Things”, 2024 14th International Symposium on Communication Systems, Networks and Digital Signal Processing.