Institut des Nanotechnologies de Lyon UMR 5270

LISV Laboratoire d'ingénierie des systèmes de Versailles

UVSQ université PARIS-SACLAY

Internship Proposal

Feb. - Sept. 2023

Evaluation of an optical wireless communications (LiFi) solution using single photon avalanche photodiodes (SPAD) as a receiver

General Context

LiFi (from light fidelity or visible light communications, VLC) is a technology that is being developed using LED lighting to create an optical wireless communication channel (equivalent to WiFi for EM waves). LiFi is limited to short-distance communications (1-10m) and has advantages over WiFi (see the table on the right and [1]).

	RF ET MICRO-ONDES	LI-FI
Spectre disponible	300 GHz	380 THz
Complexité	Élevée	Faible
Couverture	Longue portée	Limitée à la zone d'éclairage
Interférence - bruit	Limité	Contenu
Interférence électromagnétique	Oui	Non
Consommation de puissance	Moyenne	Faible
Infrastructure	Points d'accès	Éclairage installé

The LiFi applications are currently rather niche: hospitals, aircraft/space (no RF interference), classrooms (low-cost installation) ... the military or any application requiring data confidentiality. LiFi uses a modulated source (infrared or visible LED, VECSEL[1], laser…) which transmitted light signal propagates through free space before being detected by a photodetector (in general an avalanche photodiode or a PiN photodiode).

INL and LISV are working respectively on the development of new single photon avalanche photodiode (SPAD[2]) architectures [2], and on the high level modelling of LiFi communication chains including models of the hardware components and of the propagation channel, as well as advanced models of the modulation and multiple access protocols [3].

Innovative Aspect and Objectives of the Internship

Precursory works studying SPADs as photodetectors are appearing and highlight the good potential of such receivers (as a replacement for existing solutions based on avalanche or PiN photodiodes) thanks to their high speed and high sensitivity [4-7]. The current SPAD-based demonstrators are mainly based on commercially available SPADs in non-integrated receivers.

With this internship, we would like to conduct a feasibility study based with the following objectives:

- to pursue the modelling of a LiFi communication link using a receiver made of SPADs,
- to evaluate the performance (maximum throughput, bit-error-rate) as a function of the characteristics of the SPAD (dead time, noise, detection efficiency, pixel size, matrix size etc.),
- to compare the state of the art with the usual solutions (APD or PiN).

In addition to this simulation work, practical tests will be carried out on an open-source platform (PiN photodiode-based receiver). Then a pre-study will focus on the modification of the reception part of this platform to design a stage based on a commercial SPAD detector.

The final goal would be to design an integrated LiFi receiver in CMOS technology based on SPAD.

Références

[1] J. Garcia-Marquez, S. Topsu ''Les communications par lumière visible : Le Li-Fi'' Photoniques Numéro 86, Mai-Juin 2017, pp. 22-24, https://doi.org/10.1051/photon/20178622.

[2] T. Chaves de Albuquerque, F. Calmon, R. Clerc, P. Pittet, Y. Benhammou, D. Golanski, S. Jouan, D. Rideau, A. Cathelin "Integration of SPAD in 28nm FDSOI CMOS technology" ESSDERC 2018, 3-6 sept. 2018, Dresden, Germany, http://dx.doi.org/10.1109/ESSDERC.2018.8486852.

[3] M. Merah "Conception and realization of an indoor multi-user Light-Fidelity link", Thèse de l'Université Paris-Saclay, 2019.

[1] Vertical- External- Cavity Surface- Emitting Laser

[2] Single Photon Avalanche Diode

[4] L. Zhang et al. "A Comparison of APD- and SPAD-Based Receivers for Visible Light Communications," in Journal of Lightwave Technology, vol. 36, no. 12, pp. 2435-2442, 15 June 15, 2018, https://doi.org/10.1109/JLT.2018.2811180.
[5] Y. Li et al. "Performance Analysis of SPAD-based OFDM" 2019, https://arxiv.org/abs/1905.06302.
[6] S. Huang and M. Safari "Hybrid SPAD/PD Receiver for Reliable Free-Space Optical Communication," in IEEE Open Journal of the Communications Society, vol. 1, pp. 1364-1373, 2020, https://doi.org/10.1109/OJCOMS.2020.3023009.
[7] Z. Ahmed, R. Singh, W. Ali, G. Faulkner, D. O'Brien and S. Collins, "A SiPM-Based VLC Receiver for Gigabit Communication Using OOK Modulation," in IEEE Photonics Technology Letters, vol. 32, no. 6, pp. 317-320, 15 March15, 2020, https://doi.org/10.1109/LPT.2020.2973200.

Location of the internship and supervision

- Main location : Laboratoire d'Ingénierie des Systèmes de Versailles (LISV). Université de Versailles Saint-Quentin-en-Yvelines (https://www.lisv.uvsq.fr/)
- Occasional travel possible : INL - Institut des Nanotechnologies de Lyon (UMR CNRS 5270), Campus LyonTech-La Doua, 3 avenue Enrico Fermi, Bâtiment Irène Joliot Curie, Villeurbanne (https://inl.cnrs.fr/)
- Supervisors : Bastien Béchadergue (LISV) / Francis Calmon, Thibauld Cazimajou (INL, Team DE) & Fabien Mandorlo (INL, Team i-Lum).

Duration and Gratification

Internship (5-6 months from Feb. 2023) with a gratification of around 600€/month.

Expected Profile

Master M2 or engineer in Electronics, Microelectronics and/or Telecommunications.

How to Apply?

Send an email with a CV, a motivation letter and M1/M2 grades to: bastien.bechadergue@uvsq.fr and francis.calmon@insa-lyon.fr