



**HAL**  
open science

## Full frequency duplex link over 645m in the 300 GHz band

A Renau, C Maye, D Wrana, S Hausmann, I Kallfass, L John, B K Jung, U Hellrung, P Schlegel, T Kuerner, et al.

► **To cite this version:**

A Renau, C Maye, D Wrana, S Hausmann, I Kallfass, et al.. Full frequency duplex link over 645m in the 300 GHz band. Journée du Club Optique Micro-ondes (JCOM 2023), Jun 2023, Visio conference, France. hal-04160795

**HAL Id: hal-04160795**

**<https://hal.science/hal-04160795>**

Submitted on 12 Jul 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

## Full frequency duplex link over 645m in the 300 GHz band

A. Renau<sup>\*1</sup>, C. Maye<sup>1</sup>, D. Wrana<sup>2</sup>, S. Haussmann<sup>2</sup>, I. Kallfass<sup>2</sup>, L. John<sup>3</sup>, B.K. Jung<sup>4</sup>, U. Hellrung<sup>4</sup>, P. Schlegel<sup>4</sup>, T. Kuerner<sup>4</sup>, R.P. Braun<sup>5</sup>, Y. Leiba<sup>6</sup>, T. Kawanishi<sup>7</sup>, S. Hisatake<sup>8</sup>, K. Kondou<sup>9</sup>, P. Szriftgiser<sup>10</sup>, G. Ducournau<sup>\*1</sup>

<sup>1</sup>Univ. Lille, CNRS, Centrale Lille, UPHF, JUNIA, UMR 8520 - IEMN, F-59652 Villeneuve d'Ascq, France

<sup>2</sup>Institute of Robust Power Semiconductor Systems (ILH), University of Stuttgart, Stuttgart, Germany

<sup>3</sup>Fraunhofer IAF, Fraunhofer Institute for Applied Solid State Physics, Freiburg, Germany

<sup>4</sup>Technische Universität Braunschweig, Institut für Nachrichtentechnik, 38106 Braunschweig, Germany

<sup>5</sup>DEUTSCHE TELEKOM AG, Winterfeldtstr. 21, 10781 Berlin, Germany,

<sup>6</sup>Siklu Communications Ltd., Petach Tikva, Israel

<sup>7</sup>Faculty of Science and Engineering, Waseda University,

<sup>8</sup>Faculty of Engineering, Gifu University, 9HRCR Research and Development Partnership,

<sup>10</sup>PhLAM Laboratoire de Physique des Lasers, Atomes et Molécules, 59650 Villeneuve d'Ascq, France

\*[alexandre.renau@univ-lille.fr](mailto:alexandre.renau@univ-lille.fr), [guillaume.ducournau@univ-lille.fr](mailto:guillaume.ducournau@univ-lille.fr)

**Abstract**—We present here a demonstration of THz transmission system enabling a full frequency duplex link in the 300 GHz band. This system is coupling a super-heterodyne architecture, E-band modems and duplexing system at 300 GHz.

**Keywords** — THz, wireless millimetre/sub-mm technologies.

### I. INTRODUCTION

Terahertz (THz) transmissions systems are getting more and more attention for the 6th generation of cellular wireless communications that requires backhaul links with very high data-rate. Beyond the D-band (140-170 GHz) that is envisioned to start to be used within next 5 years, the 300 GHz will be the next step towards 100 Gbit/s backhails. Many system approaches are considered ahead of these future backhails, but almost all demonstrations rely on unidirectional links. We propose here the validation of a full duplex system and demonstrate a full-duplex link on a single antenna pair over 645 m.

### II. LINK ARCHITECTURE AND PERFORMANCE

The link architecture is based on a super heterodyne approach which is able to up-convert traditional backhauling frequencies (< 100 GHz) up to the THz range and thus enabling channel aggregation. It was first demonstrated in [1], then it was shown that this approach enabled to meet the new IEEE 802.15.3d THz communication standard [2]. Targeting real implementation of THz backhails in super heterodyne architecture, it is relevant to make the system compatible to a single antenna pair to simplify the alignment constraints for the expected outdoor use cases. This can be achieved with a duplexing system as shown in the figure 1. In this figure, a set of two up/down converters are used to reach the 300 GHz band, where  $f_{\text{THz}} = 3 \cdot f_{\text{LO}} + f_{\text{IF}}$ , with  $f_{\text{LO}} = 73.333$  GHz, and  $f_{\text{IF}} = 74.6$  GHz or  $84.6$  GHz.

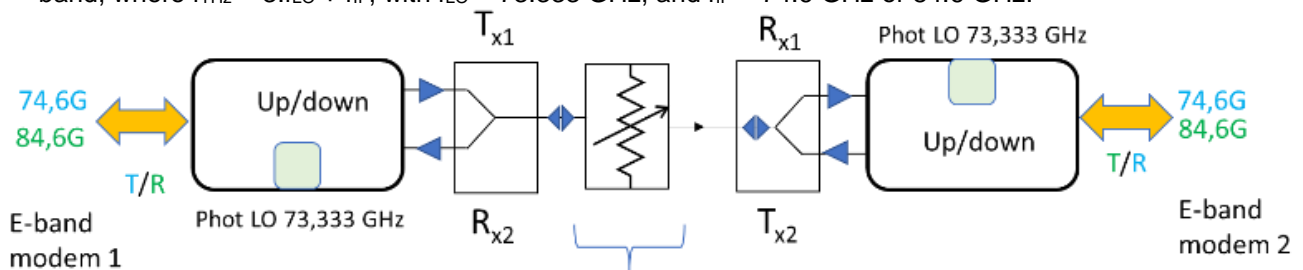


Figure 1: System architecture: two E-band modems with 10 GHz frequency spacing (74.6 and 84.6 GHz) are up/down converted into the 300 GHz band (295 and 305 GHz). The local oscillators are in this case achieved using a photomixing approach to avoid spurious tones in the LO signal at 73.333 GHz.

### III. BACK TO BACK PERFORMANCE

In order to estimate the link margin and the system is first testbed in back to back (B2B) case (ie with an attenuator between the T/R up/down converters, located at both ends. The modems in E-band are integrated with a monitoring system that enable to check the carrier to interference plus noise ratio (CINR), with a limit of 19 dB to be able to handle a QAM-32 signal. The channel bandwidth was here fixed by the E-band modem to 2.16 GHz, and the maximum net data-rate was 6.26 Gbit/s in each direction (total 12.52 Gbit/s). The data-rate was measured with the IPERF tool [3] dedicated for the testing of IP networks.

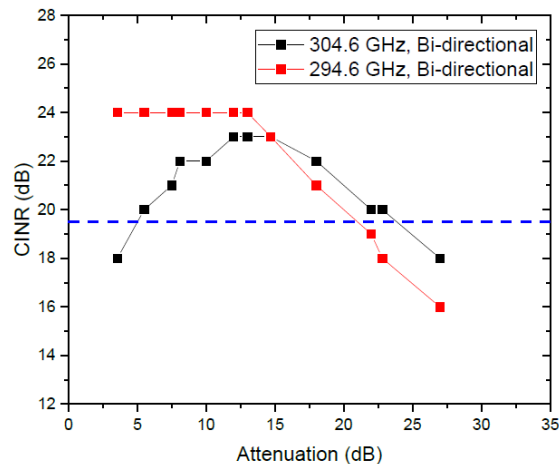


Figure 2 : Back to back test of the THz duplexed FSS system. For a QAM-32 operation, the system margin was evaluated to 21 dB.

The THz link was then successfully tested in an outdoor configuration with a pair of two Cassegrain antennas (62 dBi) over a 645 m distance, with a QAM-32 performance (12.52 Gbit/s).



Figure 3: Outdoor validation of the duplexed link over a 645 m distance.

#### Références :

- [1] I. Dan, G. Ducournau, S. Hisatake, P. Szriftgiser, R. -P. Braun and I. Kallfass, "A Terahertz Wireless Communication Link Using a Superheterodyne Approach," in IEEE Transactions on Terahertz Science and Technology, vol. 10, no. 1, pp. 32-43, Jan. 2020, doi: 10.1109/TTHZ.2019.2953647.
- [2] D. Wrana, Y. Leiba, L. John, B. Schoch, A. Tessmann and I. Kallfass, "Short-Range Full-Duplex Real-Time Wireless Terahertz Link for IEEE802.15.3d Applications," 2022 IEEE Radio and Wireless Symposium (RWS), Las Vegas, NV, USA, 2022, pp. 94-97, doi: 10.1109/RWS53089.2022.9719954.
- [3] IPERF Software [Online]. Available <https://iperf.fr/iperf-download.php>