

All-Photonic Heterodyne sub-THz Wireless Transmission at 80 GHz, 120 GHz and 160 GHz Carrier Frequencies

Citation for published version (APA):

Morales, A., Nazarikov, G. I., Rommel, S., Okonkwo, C., & Tafur Monroy, I. (2021). All-Photonic Heterodyne sub-THz Wireless Transmission at 80 GHz, 120 GHz and 160 GHz Carrier Frequencies. In *2020 45th International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz 2020* (pp. 400-401). Article 9370506 IEEE Computer Society. <https://doi.org/10.1109/IRMMW-THz46771.2020.9370506>

DOI:

[10.1109/IRMMW-THz46771.2020.9370506](https://doi.org/10.1109/IRMMW-THz46771.2020.9370506)

Document status and date:

Published: 11/03/2021

Document Version:

Accepted manuscript including changes made at the peer-review stage

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

All Photonic Heterodyne sub-THz Wireless Transmission at 80 GHz, 120 GHz and 160 GHz Carrier Frequencies

A. Morales, G. I. Nazarikov, S. Rommel, C. Okonkwo and I. Tafur Monroy

Department of Electrical Engineering, Eindhoven University of Technology, 5600 MB Eindhoven, Netherland

³Email: a.morales.vicente@tue.nl

Abstract— We experimentally demonstrate a link using a p-i-n photodiode and a photoconductor without any bandwidth-limiting electronic component. As a proof-of-concept, a 100 Mbit/s BPSK stream is successfully transmitted at three different channels with 40 GHz difference using a 3.7 GHz intermediate frequency for signal reception. Optical frequency combs are used for THz generation and detection to reduce the phase noise of the system.

I. INTRODUCTION

THz communications based on photonics offer sufficient bandwidth and flexibility to reach the capacity demands of future wireless links [1]. However, current realizations of THz links still rely on amplifiers and/or electronic receivers [1], which prevent these systems from exploiting the full potential of THz range. The future of bidirectional ultra-high capacity THz communications is therefore linked to optoelectronic techniques at both ends of the communication link, potentially achieving modulation bandwidths of several gigahertz, tunable ranges for the wireless carrier above one hundred gigahertz as well as the flexibility to multiplex several channels in frequency. Although some works have already attempted to establish a communication link fully based on photomixing technology [2,3], an experimental demonstration of broadband data transmission covering a wide range of the THz spectrum is still missing, mainly due to power limitations.

II. EXPERIMENTAL SETUP AND RESULTS

The proposed system (Fig. 1) is based on a p-i-n photodiode as transmitter and a photoconductor as receiver, both driven by signals extracted from independent optical frequency combs (OFC) to reduce phase noise, allowing phase modulation formats. The comb at the transmitter is achieved by a laser and a phase modulator driven by a local oscillator with frequency $f_{\text{comb,tx}}$, which sets the repetition rate (30 – 40 GHz). One of the comb lines is modulated by a Mach-Zehnder modulator biased at the null point and driven by a polar non-return-to-zero signal, resulting in a 100 Mbit/s binary phase shift keying (BPSK) signal. The OFC at the receiver is obtained from a picosecond

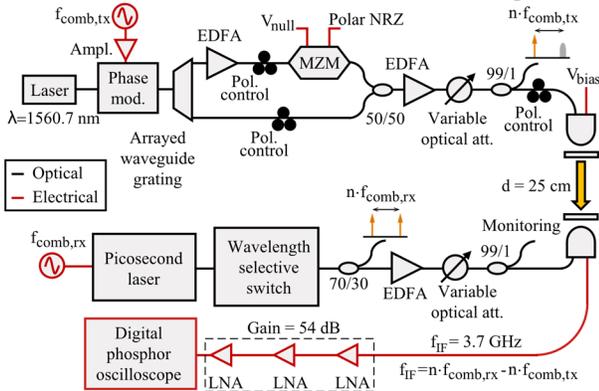


Fig. 1. Schematic of experimental setup for an all-photonic THz wireless link.

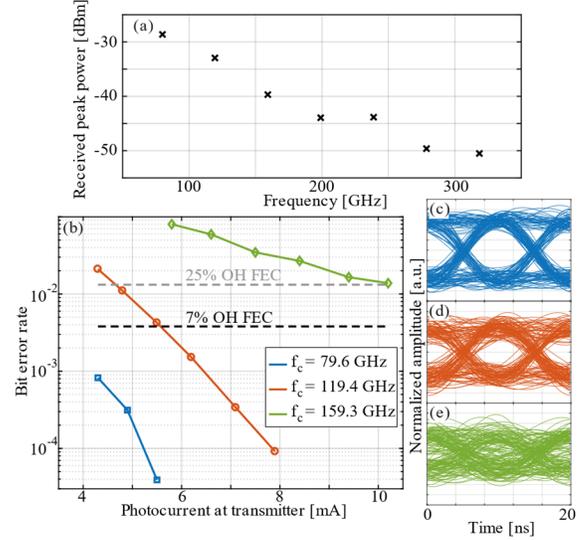


Fig. 2. Experiment results: (a) THz spectrum, (b) bit error rate curves and eye diagrams when the photocurrent at the transmitter is 10 mA and the wireless carrier is (c) 79.6 GHz, (d) 119.4 GHz and (e) 159.3 GHz.

laser with repetition rate of $f_{\text{comb,rx}} = 40$ GHz.

The wireless carrier and intermediate frequency can easily be set by filtering the proper comb lines (in 40 GHz steps) and varying the difference in the repetition rate between the two OFCs (see Fig. 1). The received signal at 3.7 GHz is amplified and captured by a sampling oscilloscope for off-line processing.

Fig. 2(a) shows the detected THz power at the intermediate frequency without modulation. The shape agrees with the THz power profile of the transmitter and the free-space transmission losses. Figs. 2(b)-(e) present the results after demodulating the data with a Costas Loop (without further equalization). The bit error rate (BER) is below 10^{-5} at 80 GHz and 120 GHz for the maximum transmitted power, while it deteriorates to the limit of error correction techniques with 25% overhead when the carrier frequency is increased to 160 GHz.

III. CONCLUSION

The presented work demonstrates a heterodyne sub-THz wireless link for transmission at frequencies between 80 GHz and 160 GHz with scalability prospect to higher THz frequencies. These results are a significant step towards highly tunable THz communications and a full exploitation of the THz range for ultra-broadband communications.

REFERENCES

- [1] T. Nagatsuma, *et al.*, “Advances in terahertz communications accelerated by photonics,” *Nat. Photonics*, vol. 10, no. 6, pp. 371 - 379, 2016.
- [2] T. Harter, *et al.*, “Wireless Multi-Subcarrier THz Communications Using Mixing in a Photonconductor for Coherent Reception link utilizing non-zero dispersion-shifted fiber,” in *Proc. IEEE Photonics Conf.*, pp. 147, 2017.
- [3] A. D. J. Fernandez Olvera, *et al.*, “W-Band Heterodyne Wireless System with 2.3 GHz Intermediate Frequency Driven Entirely by ErAs: In (Al) GaAs Photoconductors,” in *IEEE Int. Conf. Transparent Opt. Networks.*, pp. 1, 2019.